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DOCUMENTING AND EXPLAINING BIRTHWEIGHT TRENDS IN THE UNITED STATES, 1989-2007

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DOCUMENTING AND EXPLAINING BIRTHWEIGHT TRENDS IN THE UNITED STATES, 1989-2007

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Documenting and Explaining Birthweight Trends in the United States, 1989-2007

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Abstract: Birthweight is one of the most important health indicators for a newborn infant. Birthweight at either the lower or higher end is associated with adverse health outcomes in later life. In recent years, birthweight distribution in the United States has shifted to the lower end. This dissertation uses US vital statistics data from 1989 to 2007 to document recent birthweight trends in the US and examines the possible causes behind the trends. Results are reported for all births and by race/ethnicity/nativity. Descriptive analysis suggests that the lowering birthweight trend is the result of the rapid increase of lower-birthweight multiple births and decreasing birthweight among singleton births. The lowering birthweight is reflected in all birthweight measures. Low-birthweight rate is rising, mean birthweight is declining, and the proportion of macrosomic infants is decreasing. While this trend is most pronounced among US-born non-Hispanic whites and least among non-Hispanic blacks, it is prevalent among all race/ethnicity/nativity groups. Regression results suggest that much of the birthweight trend can be explained by shortened gestational age but common maternal socio-demographic, health and behavioral, and health care and medical intervention factors cannot fully explain the birthweight trend. Regression decomposition concludes that both

the trends in maternal factors and the changes in the effects of these factors on birthweight contribute to the birthweight trend. Trend in gestational age is the biggest contributor, contributing more than 100% to the birthweight trend, while improvement in education, reduction of smoking during pregnancy and improvement in prenatal care have slowed down the birthweight decrease. Further research needs to be done to identify factors leading to the recent birthweight trend that are not available from the vital statistics.

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Chapter 1: Introduction and Statement of the Problem

Important trends in birthweight have been observed in the United States in the last two decades. After a continuous rise in mean birthweight and a decrease in the proportion of infants born with low birthweight (<2500 grams [g]) before the late 1980s, more recently the distribution of birthweight began to shift toward the lower end. Although a sharp increase in twin and other multiple births that has occurred around the same time has contributed to the shift, the downward trend in birthweight also holds true when only singletons are examined. According to the National Vital Statistics Reports (Martin et al. 2009), the percent of singleton babies born with low birthweight was 6.49% in 2006 as compared to 5.9% in 1990. Mean birthweight was 3,298 grams in 2006, 67 grams lower than the 1990 level, which reflects a total shift of the full birthweight distribution. The proportion of babies on the lower end of the birthweight spectrum (birthweight less than 3,500 grams) is on the rise whereas the proportion for those on the heavier end is declining.

These trends are of special concern because birthweight is considered to be a major health indicator for newborns. Studies have found that the relationship between birthweight and infant mortality follows a U-shaped pattern, with infants weighing between 3,250g to 4,000g having the lowest risk for infant mortality (Wilcox and Russell 1983; Solis et al. 2000) or perinatal mortality (Samaras et al. 2003). Thus, birthweight on either side of the spectrum is unfavorable. Infants born with low birthweight are much more likely to die before their first birthdays and are associated with adverse health outcomes in later years of life (Cramer 1987; Frisbie et al. 1996; Hack et al. 1995). Babies born with heavier birthweight, on the other hand, are at higher risk for overweight and obesity in childhood and adult life (Rogers 2003). A positive and statistically significant increased risk for adult cancer was also found with increasing birthweight (Anderson et al. 2001). Therefore, the shift toward a lighter birthweight distribution may ease our worries about the increase of heavy birthweight babies that have occurred in other countries, while the increase in low birthweight babies, and more importantly, the decrease in the proportion of babies born with the most favorable birthweight (3,000g to 4,000g) should be monitored and the reasons behind it need to be studied.

Birthweight trends in the United States are further intriguing because trends in birthweight have gone in a different direction in some European countries and Canada around the same period of time. Sweden saw an increase in mean birthweight and the proportion of babies born with birthweight over 4,500g, and the risk for large-for-gestational-age (LGA) birth increased by 23% between 1992 and 2001 (Surkan et al. 2004). In Berlin, mean birthweight remained constant between 1993 and 1999. However, the rates for birthweight over 4,000g rose from 9.1% to 10.1% (Bergmann 2003). In Norway, birthweight of term babies increased for all gestational weeks between 1967 and 1998. In Scotland, England and Wales, the percentage of babies born with heavier birthweight (>3500g) has been increasing at an annual rate of between 0.35% and 0.40% since 1983 (Power 1994).

Many have attributed the trends of heavier babies in Europe and Canada to the increase in mothers' weight and height, the rise in the prevalence of diabetes, the increase of mothers' age at childbirth and the decrease in cigarette smoking during pregnancy (Kramer et al. 2002; Wen et al. 2003; Bergmann et al. 2003; Surkan et al. 2004). Some speculated that this trend in heavier birthweight has contributed to increasing trends of childhood overweight, adult obesity, and diabetes which in turn, contributes to the upward trend of heavier babies across generations. The concern is that the snowball effects will aggravate the obesity epidemic.

The United States has experienced the same trend of a rapidly rising rate of obesity and diabetes as other developed countries. The prevalence rate of obesity among women doubled since 1980 (Flegal et al. 2002). Yet, the United States has not experienced an increasing trend of heavier babies. Instead, the whole distribution of birthweight has shifted to the lower end. No studies, to the author's knowledge, have examined in depth the causes behind this down turn in the United States birthweight distribution. But related studies (reviewed in the next chapter) suggest that recent U.S. trends in the management of labor and delivery and changes in some of the maternal demographic and health factors may have contributed to the trends in birthweight.

Parallel to the U.S. shift to a lower birthweight distribution is a shift toward shorter gestational age. Again, although the increase of multiple births, who tend to be born earlier, may have partly driven the trend, shorter gestation is also observed among singleton births. The preterm birth (gestational age less than 37 weeks) rate rose from 9.70% in 1990 to 11.09% in 2006, equaling a 14% increase (Martin et al. 2009). Gestational age is also shorter among term babies in recent years. The proportion of babies born between 37 and 39 weeks of gestation increased from 41.42% in 1990 to

55.05% in 2000, whereas that for births higher than 40 weeks dropped from 48.88% to 33.85%. As the most immediate predictor of birthweight, the shortened gestational age distribution has no doubt contributed to the lighter birthweight distribution.

As important as gestational age is to explaining the trend in birthweight, recent trends in the management of labor and delivery may have been the major cause of shortened gestational age and is of substantial importance for this research. A study by Bettegowda et al. (2008) found that the increase in the preterm birth rate has occurred mainly among infants delivered by cesarean section. Between 1996 and 2006, cesarean rates increased for births at all gestational ages. Similarly, induction rates have more than doubled between 1990 and 2000 and increased for births at all gestational age categories. Part of this rise may have been due to the rise in elective inductions (Grobman 2007).

Changes in maternal demographic and health factors may have also been important contributors to the trends in birthweight described above. One of the factors that may have been closely related to the recent trends in lowered birthweight is maternal age. The relationship between maternal age and birthweight is U-shaped, with teenage mothers and women over 40 who have their first births at the highest risk for low birthweight (Martin et al. 2006). During the period between 1991 and 2006, birth rates for women aged 10-19 years declined. However, the rate for women aged 40 and over increased dramatically. The birth rate to women 40-44 years old reached 9.4 per 1000 women in 2006, the highest level in 40 years.

While changes in maternal factors play an important role in explaining the trends in birthweight, changes in the relationship between these factors and birthweight are yet another part of the story. Between 1990 and 2006, low birthweight rates increased for women aged 20 to 40, who are at the lowest risk for low birthweight. In fact, an analysis by Young et al. (2006) found that changes in age- and parity-specific rates played a more important role in the changes of low birthweight rate between 1980 and 2000 than changes in the age-parity distribution. The study by Davidoff et al. (2006) also found that among singleton births, the largest increase in the proportion of late pre-term births occurred to non-Hispanic white infants between 1992 and 2002. Among non-Hispanic black infants, who are at higher risk for preterm birth, the proportion of births decreased at every gestational age less than 36 weeks.

Because of the link of low birthweight to infant mortality and unfavorable health outcomes, reducing the rate of low-birthweight infants (to 5.9% by 2010) was one of the US objectives of Healthy People 2010 (http://www.healthypeople.gov/data/midcourse/html/focusareas/FA16Objectives.htm. Accessed 18 April 2010). Recent trends in birthweight as discussed above, however, suggest that we are diverging away from that goal. Thus, a study on the causes and implications of these trends is important and necessary in out attempt to improve maternal, infant, and child health in the United States.

A notable trend in recent years is that the rate of low birthweight and short gestation births have been rising among women who are considered to be at low risk for these adverse birth outcomes, for example, those aged 20 to 44 and non-Hispanic white women. This implies a change in the relationship between maternal risk factors and birth outcomes that is also worth further investigation. It is important for public health promotion because it may point to a different target for intervention then was previously believed.

Overall, then, the aims of this dissertation are: 1) to thoroughly describe temporal trends in birthweight in the United States between 1989 and 2007 among singletons and plural births; 2) to investigate the compositional change effects of social and demographic, health and behavioral, and health care and medical causes behind these trends; 3) to determine the percentage contributions of compositional changes and effect changes of maternal characteristics to the birthweight trend; 4) to examine whether the effect of the above factors on the birthweight trends vary across race/ethnic groups.

Following this chapter of introduction, Chapter 2 provides a background for current research and a review on previous research relating to the topic under discussion. Chapter 3 discusses data, measures and methods that will be used for this dissertation. Chapter 4 provides descriptive results of the overall trend and race/ethnic/nativity trends in birthweight in the US since between 1989 and 2007. Multivariate regression analyses are conducted in Chapter 5 on birthweight trends for all singleton births and by race/ethnicity/nativity to determine whether birthweight trends are explained by compositional changes in its covariates. In Chapter 6, changes in birthweight between 1989 and 2007 are decomposed into changes due to compositional changes of each covariate and changes due to the effects of each covariate. The regression decomposition results are examined for all singleton births and by race/ethnicity/nativity. Finally, Chapter 7 includes a summary of results, a discussion of findings relative to previous literature, study limitations, and a discussion of the implications for future research and social and health policy.

CHAPTER 2: BACKGROUND AND PREVIOUS RESEARCH

HISTORICAL AND RECENT TRENDS IN BIRTHWEIGHT DISTRIBUTION IN THE UNITED STATES

Singleton Births

The majority of newborns are singleton births. They are naturally also the main subjects of most reports and studies on birthweight. Most singleton infants are born with birthweight between 2,500g and 5,000g. A very small percentage of them, however, are born with low birthweight, that is, birthweight under 2,500g. An even smaller percentage is born with very low birthweight, under 1,500g. Low and very low birthweight are unfavorable because of their association with much higher risk of infant mortality and adverse health outcomes in later life.

The mid and late 20th century saw a general trend of increase in birthweight among singleton babies in the United States. Between 1960 and 1980, for example, the low birthweight rate declined from 6.82 to 5.96 percent for all singleton births. Meanwhile, those born with birthweight over 4,500g increased from 1.58 to 1.87 percent. In fact, the proportion of babies in all the categories under 2,500g decreased while those above 3,500 increased during the same period (Kessel et al. 1984; Buehler et al. 1987). As reported by the US Centers for Disease Control and Prevention (CDC) in its low birthweight trend table (www.cdc.gov/nchs/hus/updatedtables.htm. Accessed 18 April

2010), the percentage of live births under 2,500g dropped almost every year during the 1970s and 1980s, from 7.93 percent in 1970 to 6.93 in 1988.

Since the end of the 1980s, however, the trend for birthweight changed direction. Most of the years in the 1990s and 2000s saw an increase in the rate of low birthweight. As a result, the percentage of low birthweight increased from 7.12 in 1991 to 7.57 in 2000 and continued to rise to 8.26 in 2006. The shift toward a lower birthweight distribution is also reflected among the normal birthweight groups. Of all babies born with birthweight greater than 2,500g, 42.9% had birthweight over 3,500g in 1991, but this number dropped to 41.8% in 2000 and even further to 37.5% in 2006 (Centers for Disease Control and Prevention. National Center for Health Statistics.VitalStats.http://www.cdc.gov/nchs/vitalstats.htm. Accessed 18 April 2010).

Multiple Births

Twin and other multiple births account for a very small proportion of live births every year. In 2005, the rate for twin births was 32.2 per one thousand live births and the rate for triplets and higher order multiples was 161.8 per 100,000 live births. A sharp increase in the rates for twins and higher-order births began in the 1980s and has continued. This trend resulted in a 70% increase in multiple births in 2005, as compared to 1980 (Martin et al. 2007).

Twin and other multiple births run a much higher risk of low birthweight than singleton births. In 1995-1997, 53.6% of the twin births and 93.2 of the triplets or higher order births were born under 2,500g (Blondel et al. 2002). No reports or studies to date have offered a comprehensive description on the changes of birthweight of twins and triplets over the last 15 years. Blodel et al. (2002) compared the birthweight of twins and triplets in the two periods of 1981-1983 and 1995-1997 and reported a slight increase in the rate of low birthweight, but the increase in the number of twins and triplets has contributed to an increase in the overall low birthweight rate.

Preterm Births

Most infants are born between 37 and 40 weeks of gestation. Babies born at or before 36 weeks of gestation are preterm, while those born between 37 and 40 weeks of gestation are at term and those over 40 weeks are post-term births.

Gestational age and birthweight are closely related. In 2006, 43.1% of preterm babies had birthweight under 2,500g, whereas only 3.1% of term and post-term babies were born with low birthweight. On the other hand, while only 0.04% of all the term babies were born over 4,500g, that percentage was 7% for post-term babies in 2006.

It is not surprising that the downward trend of birthweight coincides with a trend toward shorter gestational age in recent decades. In 1990, 10.61% of live births were preterm and 48% were born at or after 40 weeks. In 2006, however, the rate for preterm rose to 12.8% but the rate for gestational age 40 weeks and longer dropped to 32.88% (Martin et al. 2009). It is unclear, though, how much of the decrease in birthweight can be attributed to the shortening of gestational age.

Racial/ethnic Disparities

There are wide disparities in birthweight distribution among U.S. race/ethnic groups, especially between blacks and whites. Infants born to black women are about twice as likely to be low-birthweight than infants born to white women, although the differences in birthweight between blacks and whites has changed over the years. In 1960, for example, the low-birthweight rate was 5.95% for whites and 11.99% for blacks. In 1980, the percentage dropped to 4.88% for whites, an 18% decrease, but to just 11.29% for blacks, only a 6% decrease. The relative lack of improvement for birthweight for blacks was true on the other end of the birthweight spectrum as well. Between 1960 and 1980, the percentage of singletons born over 4,500g increased from 1.64 to 2.11 for whites but decreased for blacks from 1.28% to 0.82%.The widening of the differences continued in the 1980s, but reversed in the 1990s. More recently, the low-birthweight rate for whites increased from 4.55% in 1990 to 4.88% in 2000, whereas that for blacks decreased from 11.51% to 11.15% (Young et al. 2006). These differing trends are an important part of the focus of this dissertation.

One of the reasons why black infants are at higher risk for low birthweight is the fact that they are more likely to be born preterm. In 1992, for example, 17.1% of blacks were born at or before 36 weeks of gestation, in contrast with only 10.1% of whites. Similar to the trend in birthweight, racial differences in gestational age decreased in recent decades. In 2002, the preterm birth rate among singletons rose to 10.6% for whites but decreased to 15.6% for blacks (Davidoff et al. 2006).

Black mothers have also been more likely to give births to twins and other multiple births. In 1980, the twin birth rate was 24 per 1,000 for blacks and 18.1 per 1,000 for whites, while the rate for triplets and higher order births were 88.3 per 100,000 for blacks and 37.6 per 100,000 for whites. These rates have increased in the past two decades for both races, but a much faster rate of change is seen among whites, especially if only non-Hispanic white women are considered. In 1997, the twin birth rate for blacks rose to 30 per 1,000 while that for whites rose to 26.7 per 1,000 and 28.8 per 1,000 if we only look at non-Hispanic whites, a level that is catching up with the higher black rates. Because of the small percentage of multiples among all live births, it is unlikely that these trends have been the major driving force in the changes of the black and white birthweight distributions, but they are certainly important factors to be examined when studying racial disparities in birthweight and deserve continued research attention.

Hispanic origin became an item on birth certificates in most states of the US in 1989. It enabled researchers to separate the Hispanic population from blacks and whites in the study of vital statistics at the national level. Cross-sectional comparisons among these three major race/ethnic groups found that, in general, Hispanics share a similar birthweight distribution to whites although they look more like blacks in terms of social and economic risk factors for low birthweight. This phenomenon is called the Hispanic paradox and has been widely discussed (Markides and Eschbach 2005; Hummer et al. 2007). Since 1990, the rate of low birthweight for Hispanics has been on the rise, too, from 7.4% in 1990 to 7.5% in 2000 and 8.1% in 2005 (Martin et al. 2007).

EXPLAINING RECENT TRENDS IN THE BIRTHWEIGHT DISTRIBUTION

As a health indicator, birthweight is often seen as the outcome of a host of inter-relating social and biological factors. Over the years, researchers from different disciplines have identified many of these factors that impact birthweight (reviewed below). The trend in birthweight distribution is a function of changes in these factors and the changes in the way these factors affect birthweight over time. For the purpose of organization and discussion, this section groups these predictors into maternal socio-demographic factors, maternal behavioral and health factors, and health care and medical intervention factors. The factors reviewed here are not fully exhaustive but relevant to this study. Moreover, the categories they are divided into are "overlapping" (Frisbie 2006: 252) and could be grouped differently.

Maternal Socio-economic and Demographic Factors

Race/ethnicity (discussed in a separate section below), nativity, maternal age, education, marital status, income, and birth order are among the most common socioeconomic and demographic factors associated with birthweight (Institute of Medicine 1985; Cramer 1987). Distributions of birthweight vary among infants born to women in these different groups. Therefore, the birthweight distribution of the overall population will be affected both by the changes in the composition of mothers with different socioeconomic and demographic characteristics and the birthweight distribution of infants born to a component group of mothers.

The age of mother at birth is one of the most important factors that is related to infant's birthweight. Teenage mothers and mothers over 35 are more likely to give birth to infants with low birthweight (Ventura et al. 2001; Cnattingius et al. 1992). On the other hand, mothers over 35 are also more likely to give birth to macrosomic infants (Frank et al. 2000; Boulet et al. 2003). During the last several decades, the age distribution of mothers giving births in the United States has grown much older. The mean age of new mothers rose from 24.6 in 1970 to 27.2 in 2000 and percentage of births among teenage mothers declined, whereas the percentage among mothers 35 years or older increased (Mathews and Hamilton 2002; Martin et al. 2007).

This drastic change in mother's age distribution has no doubt contributed to the trends in birthweight distribution. However, decomposition suggests that it only accounted for a small proportion of the changes in low birthweight rates from 1980 to 2000. The majority of the changes were due to the changes in age-parity specific birthweight (Young et al. 2006).

Women in disadvantaged positions in society often face higher risk for adverse health outcomes. It is no exception with birthweight. Women with low education, low income and who are not married are far more likely to give birth to infants of low birthweight (Institute of Medicine 1985; Cramer 1995), although being married is associated with a higher risk for macrosomic infants. In the past few decades, educational attainment has increased substantially among women who gave birth. This trend in and of itself should lead to increases, instead of decreases, in birthweight. The trend of marital status, however, has been a counter driving force for birthweight. In 1980, only 18.4% of all births occurred to unmarried women, but in 2000, this percentage more than doubled to 38.5% (Martin et al. 2009).

Maternal Behavioral and Health Factors

Maternal weight gain, maternal pre-pregnancy weight, paternal height and weight, pregnancy history, inter-pregnancy interval, maternal morbidity, cigarette smoking, and alcohol and other drug consumption are some of the behavioral and health factors associated with birthweight. In the past few decades in the United States, the prevalence of obesity doubled among women age over 20. It rose even more for the primary fertility age groups, that is, those between 20 and 39, from 12.3% in 1976-1980 to 28.4% in 1990-2000 (Flegal 2002). Since pre-pregnancy weight is positively associated with birthweight (Frederick et al. 2008) and heavy birthweight, in turn, is a risk factor for higher BMI and obesity in later life (Rogers et al. 2003), some speculate the root for the obesity epidemic in the United States lies in the increased maternal body size and birth size (Samaras et al. 2005). However, this hypothesis does not seem to be valid, given the recent downward trend of the birthweight distribution in the United States.

Maternal weight gain is another important and closely related but independent factor that is positively associated with birthweight (Rogers et al. 2003). It also interacts with maternal pre-pregnancy weight to affect birthweight (Dietz et al. 2006). The latest guideline put forward by the Institute of Medicine (IOM) recommended different ranges of weight gain based on pre-pregnancy Body Mass Index (BMI). The range for normal weight women is between 25 to 35 pounds. It is higher for women with lower BMI and lower for women who are overweight or obese (Rasmussen and Yaktine 2009). Data from birth certificate records suggest, however, that the percentage of women with weight gain out of the recommended range on both sides has increased sharply during the past two decades (Martin et al. 2009). Other factors being equal, this would have increased both the percentage of low birthweight and macrosomic babies.

Smoking and heavy drinking during pregnancy are both risk factors for low birthweight. Women who smoke are twice as likely as non-smokers and those who drink heavily are three times as likely as those who do not drink during pregnancy to have low birthweight infants (Chomitz et al. 1995). According to a CDC report, prevalence of binge drinking among pregnant women in the US was basically unchanged from 1991 to 2005 (Denny et al. 2009). A study based on data from ten states revealed that smoking before pregnancy remain unchanged, although quitting during pregnancy rose from 37% to 46% from 1993 to 1999 (Colman and Joyce 2003). If this trend reflects the overall trend of the nation, it would have driven the birthweight distribution upward.

Health Care and Medical Factors

Improvements in health care and advances in medical technology before and during child birth have brought about positive changes in the survival of newborns (Gortmaker & Wise 1997). However, the effectiveness of prenatal care and obstetrical procedures in preventing low birthweight is not as clear (Alexander and Korenbrot 1995; Ricciotti et al. 1995).

The most noticeable trends in terms of medical intervention in the process of child birth is the sharp rise in the use of obstetric procedures to induce labor and the rate of cesarean surgeries among all deliveries. The year 2006 saw the highest level of total cesarean delivery rate in the United States. Almost one in three deliveries involved a cesarean surgery, as compared to one in four or five in the 1990s (Martin et al. 2009). The increase in the rate of induction of labor among all births is also stunning. It has more than doubled since 1990, rising from 9.5% to 22.5% in 2006.

The increasing trends in induced labor, cesarean sections and other medical interventions have contributed to the shift toward earlier gestations, which in turn, impacted the downward trends in birthweight (Davidoff et al. 2006). In analyzing the impact of cesarean section on gestational age among singleton births, Bettegowda et al. (2008) found that singleton preterm birth rates increased from 9.7% in 1996 to 10.7% in 2004 and among preterm births, the percentage delivered vaginally decreased while the proportion delivered by cesarean increased. They thus concluded that the increase in preterm births is likely due to the increase in cesarean deliveries. While these studies did not evaluate the impact of induced labor and cesarean sections on the whole distribution of gestational age, they reported that the rates of induced labor and cesarean sections increased for births at all gestational weeks.

EXPLAINING RACIAL/ETHNIC DIFFERENCES IN BIRTHWEIGHT TRENDS

As described above, racial/ethnic differences in birthweight, especially those between black and white infants, have long been documented and have never disappeared in the United States, despite the effort made and programs designed to eliminate them (Stevens and Orleans 1999). A great amount of research has also been done in explaining racial/ethnic disparities, but no studies so far have been able to explain birthweight differences between black and white infants. However, researchers have identified a range of contributing factors and developed conceptual models to study racial/ethnic disparities in mortality and health (Mosley and Chen 1984; Hummer 1996) in general and infant mortality and health outcomes specifically (Wise 2003). These models serve as a general framework in defining the causes behind differential birthweight trends among the major race/ethnic groups. It is beyond the scope of this dissertation to discuss all aspects of birthweight disparities, but a few highlights of the major predictors and their changes seen in recent years should shed light on our understanding of the differential racial/ethnic trends in birthweight.

Perhaps the most important contributors to the black and white differences are the social and economic disadvantages of the black population. These disadvantages exist at the very beginning of life. Compared to their white counterparts, black infants are more likely to be born to women between 15-19 years of age, to unmarried women and to women who do not have high school diplomas. These risk factors place blacks at higher risk for low birthweight. While these remain true, important changes in the social and demographic characteristics have taken place among white and black mothers who give birth. For example, birth rates of unmarried women age 15 to 44 have dropped from 90.5 to 71.5 for blacks but have risen from 24.4% to 32% for non-Hispanic whites between

1990 and 2006. Another notable trend is that some low-risk groups, for example, those between ages 20 and 44, have seen a significant increase in the rate of low birthweight (Martin et al. 2009). This change will likely affect blacks and whites differently due to the different demographic compositions of the two groups.

Health care and medical interventions have been viewed as intervening factors that can mediate the pathways of social influences on health outcomes. Large disparities exist in prenatal care receipt, despite improvement for all race/ethnic groups. For example, Non-Hispanic blacks are more than twice as likely as non-Hispanic white women to receive late or no care (Martin et al. 2009).

One of the important trends in recent years is the increasing use of medical services before, during and after child birth. And the role of medical interventions in their effect on maternal and infant health has never been more controversial. While advancement in medical technologies have improved the chance of pregnancy for women and the survivability of infants, increased use of some of these technologies, namely, Assisted Reproductive Technologies (ART), induction of labor, and cesarean deliveries have been linked to a shortened gestational age distribution and an increase in preterm births (Laura et al. 2004; Davidoff et al. 2006; Bettegowda et al. 2008). These changes, in turn, may result in a lighter birthweight distribution and an increase in low-birthweight infants. Although utilization of these services have increased among all race/ethnic groups, white women lead in most cases. For example, the 2006 induction rate among non-Hispanic white mothers was 26.9%, compared to 19.8% among non-Hispanic black mothers (Martin et al. 2009). The role of these new trends in medical services in birthweight disparities is not clear.

The discussion on disparities, or rather, the surprising lack of disparities in birthweight and other health outcomes between whites and Hispanics, especially foreign-born Hispanics, has revolved around the concept of "Hispanic Paradox". However, little is known about trends in birthweight among Hispanics, and particularly so for births to foreign-born Hispanic and U.S.-born Hispanic women. In this study of birthweight trends, I examine the extent to which recent trends in maternal characteristics have affected birthweight trends among race/ethnicity/nativity groups, including among both foreign-born and U.S.-born Hispanic women.

SUMMARY

This chapter has reviewed historical and recent trends in birthweight distributions in the United States that have been documented in the literature. It also focused on factors and new trends in these factors that could potentially explain recent birthweight trends. While improvements in educational attainment and reductions in smoking and heavy drinking will generally shift the birthweight distribution upward, increases in non-marital births, higher rates of induced labor, and higher rates of cesarean deliveries are expected to move the distribution in the opposite direction. On the other hand, the shift toward older age at childbearing and pregnancy weight gain out of the optimal range are likely to increase both the proportions of low-birthweight and macrosomic infants.

Accompanied by a decreasing trend in birthweight for all infants, there are signs that black-white differences in birthweight are decreasing in recent years. But this decreasing disparity is not due so much to the improvement of birthweight among blacks, but rather the increase of low birthweight among whites. This is likely the results of such factors as older age of childbearing, the rise in non-marital births and increased utilization of medical services, such as induced labor and cesarean deliveries, especially among white women.

Given these trends, my dissertation analysis aims to both comprehensively document birthweight trends and, through careful statistical analyses, understand how changes in social and demographic, health and behavioral, and healthcare and medical factors have impacted birthweight trends as well as race/ethnic differences in those trends.

CHAPTER 3: DATA, MEASURES AND METHODS

DATA

Public use birth micro data for the US from 1989 through 2007 from the National Center for Health Statistics at the Centers for Disease Control and Prevention are used for the analyses. The data contain all live birth records occurring in the United States to U.S. residents or non-residents; births in Puerto Rico and other US territories are excluded from current analyses. The standard U.S. birth certificate was revised in 2003 and as a result, some of the items are not comparable before and after the revision. For the purposes of this dissertation, only items unchanged or comparable will be used as variables in the analyses. About 4,000,000 births occurred each year in the US during the period from 1989 to 2007 and the full data contain 72,623,416 births.

MEASURES

Birthweight is the outcome variable in this study. Several measures will be used to study the birthweight distribution, each of which has its strengths and limitations. The use of multiple birthweight measures allows for a better picture of the overall trends in the birthweight distribution. Mean birthweight measures the general level of birthweight in a population. While it is simple to obtain and easy to understand, it sometimes remain unchanged or little changed when drastic changes occur in the birthweight distribution. The low birthweight rate and the very low birthweight rate measure the rates of occurrence of infants born with birthweight lower than 2,500g (LBW) and those lower than 1,500g (VLBW). The LBW rate and the VLBW rate are perhaps the most commonly used measures in the research literature because they focus on infants who are at the highest risk for infant mortality and unfavorable health outcomes in childhood and adult life. These measures, however, do not accurately reflect changes on the other end of the birthweight spectrum, the macrosomic infants, or those heavier than 4,500 g, who are also at risk for adverse health outcomes. Thus, the proportions of babies born in different birthweight categories can be calculated, for example, for those born under 1,500g, under 2,500g, 2,500g to 3,499g, 3,500g to 4,499g and over 4,500g. These proportions are simple to calculate from the birth data and capture changes over the whole spectrum of the birthweight distribution. Last but not the least are the rate of small-for-gestational-age (SGA) births and the rate of large-for-gestational-age (LGA) births. These measures take into consideration age of gestation at birth and may be better in identifying infants at risk for mortality and unfavorable health outcomes (Alexander et al. 1996; Frisbie et al. 1997; Solis et al. 2000) than measures of birthweight alone. SGA births are usually defined as birthweight less than the 10^{th} percentile and LGA births as birthweight greater than the 90^{th} percentile at a given gestational age (Alexander et al. 1996). To enable comparison of rates for SGA and LGA across years, I use the 1991 fetal growth chart developed by Alexander et al. (1996) as a reference for my calculation of all the birth data in the current analyses.

Three groups of items reported on the birth certificate are used as variables in the descriptive analyses or as explanatory variables in the regression analyses.

First, socioeconomic and demographic factors include mother's nativity, race/ethnicity, education, age, birth order, and marital status.

Mother's nativity is categorized as "US-born" and "foreign-born". Mothers whose origin is Hispanic is grouped into "Mexican" and "Other Hispanics". Non-Hispanic mothers are categorized into "black", "American Indians and Asian-Pacific Islander", "white" and a residual group "other". Mother's education on the 2003 revision of birth certificate is collapsed into four categories, "less than high school", "high school graduate", "associate degree", and "bachelor's degree or higher". Mother's education on the 1989 revision of the birth certificate is used to approximate the four categories, "No formal education, 0-8 years of elementary school or 1-3 years of high school" is the "less than high school" category, "4 years of high school" is the "high school graduate" category, "1-3 years of college" is the "associate degree" category and "4-5 or more years of college" is the "bachelor's degree or higher" category.

Mother's age is a five-category variable, "under 18", "18-20", "20-24", "25-34", and "35 and older". Birth order is the sum of all previous pregnancies plus the index birth and is categorized into "first", "second", "third" and "fourth or higher". The parity variable is constructed from the mother's age and birth order variables. Third or higher order births to women under 25 years of age or fourth or higher order births to women under 30 are defined as high parity. First births to women 30 and older are put in a separate category and all the other births are defined as low parity. Mother's marital status is either "yes" or "no".

Second, maternal health and behavior factors include weight gain, tobacco use, diabetes and hypertension.

Weight gain is recoded according to the recommended weight gain range for normal weight women, “15-25 pounds”, “under 15 pounds” and “25 pounds and up”. Detailed tobacco use information is only available in the 2003 revision and therefore the smoking during pregnancy variable is a simple two-category variable, “yes” or “no”. Diabetes and hypertension are combined into one variable, “having both diabetes and hypertension”, “diabetes only”, “hypertension only”, and “neither”.

Third, health care and medical intervention variables include prenatal care, induction of labor, cesarean section, and gestational age.

The Kotelchuck Index (Kotelchuck 1994) of prenatal care utilization is calculated and used to measure adequacy of prenatal care in four categories: “inadequate”, “intermediate”, “adequate”, and “adequate plus”. Induction of labor and cesarean section are both two-category variables, “yes” or “no”. Gestational age is a continuous variable measuring length of gestation in weeks.

METHODS

Descriptive Analyses

To provide a comprehensive picture of birthweight trends in the United States between 1989 and 2007, descriptive analyses are used to document the trends in birthweight for all births and by race/ethnicity/nativity. Separate tables are reported for singleton and multiple births for all these groups.

Regression Analyses for Overall Trends in Birthweight

To identify possible causes behind the recent trends in birthweight in the U.S., regression analyses using individual level data are conducted in Chapter 5 on various birthweight measures, more specifically, continuous birthweight in grams, low birthweight, very low birthweight, SGA and LGA, although only selected results are reported given substantial consistency across outcomes. Due to the small number of twins and multiple births each year, the regression analyses only include singleton births.

Decomposition of Birthweight Trends

Regression decomposition is utilized in Chapter 6 to study the contributions of two components to differences in birthweight between 1989 and 2007. The first (endowment) component is the difference due to compositional changes in the independent variables; and the second (coefficient) component is the difference due to effect changes in the independent variables on the outcome variable. Each analytic chapter provides more detail regarding the specific data, measures, and methods used for each analytic portion of the dissertation.

CHAPTER 4: DESCRIBING BIRTHWEIGHT TRENDS IN THE U.S., 1989-2007

In this chapter, I describe trends in birthweight in the US from 1989 to 2007 for all births and for major race/ethnic/nativity groups. While the National Center for Health Statistics regularly report general trends in birth and birth related indicators in its National Vital Statistics Reports series (http://www.cdc.gov/nchs/products/nvsr.htm. Accessed 15 July 2012), one of which focuses on birthweight, it does not go into the race/ethnic/nativity detail in the manner in which I do here. Moreover, in addition to the commonly used birthweight indicators such as mean birthweight, low birthweight rate and very low birthweight rate, I include a more in-depth set of birthweight measures, especially measures that take into consideration the length of gestation. The descriptions in this chapter provide a thorough and detailed picture on trends in birthweight in the United States between 1989 and 2007.

DATA AND IMPUTATION

Data used in this chapter are birth data for the US from 1989 to 2007. All births on record are included in Table 4.1. For the rest of the tables and figures in this chapter, however, birth records that have missing values on variables relevant to this chapter, namely, birthweight, gestational age, race/ethnicity, nativity and plurality, are deleted. A total of 2.6 percent of all births over the years are deleted as a result.

Also for the variables mentioned above, data are imputed for about 12.6 percent of all births overall by NCHS. The majority of the imputations are due to missing gestational age, which fluctuates around 11 percent of all births each year. As indicated by the Users' Guide for birth data files (ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/DVS/natality/UserGuide2007.pdf. Accessed 15 July 2012), missing data and imputed data for gestational age occur more often among "selected maternal race groups", and "births with shorter gestations". This can pose a potential bias in my analyses involving race and gestation variables. It is thus necessary to compare data with and without imputed values. I hereby report only results with imputed data when there is no significant difference in the comparison but will report both results whenever there is a sizable discrepancy.

TRENDS IN THE NUMBER AND COMPOSITION OF BIRTHS

Table 4.1 reports the number of births in the United States from 1989 to 2007. The total number of births has remained relatively constant, fluctuating around 4,000,000 each year. However, the composition of mothers by nativity has changed. Births to US-born mothers have decreased steadily while births to foreign-born mothers have been on a constant rise. As a result, the number of births to foreign-born mothers climbed to 1,076,613 in 2007 and comprises 24.9% of total births in 2007, as compared to 585,855 in number and 14.5% of total births in 1989. Figure 4.1 further breaks down the trend of births by maternal race/ethnicity/nativity. Among births to US-born mothers, the majority were to non-Hispanic whites throughout the time period. However, they also experienced a yearly decease in the number of births during this period, while births to mothers of other US-born groups remained mostly constant. Births to mothers of all the foreign-born race/ethnic groups, on the other hand, have been increasing. The biggest contributor to the increasing trend among births to foreign-born mothers is foreign-born Mexicans. With more than 450,000 births in 2007, they accounted for more than 40% of births to foreign-born mothers.

The percentage of singleton births has also changed over time, though rates of change have varied across race/ethnic groups. This is shown in Figure 4.2. First, note that the percentage of singleton births among all groups has decreased. Both US-born and foreign-born whites have experienced the greatest decrease and, in 2007, 96.2% of infants born to US-born white mothers and 96.0% of those born to foreign-born white mothers were singletons as compared to 97.7% and 97.8% in 1989. On the other hand, singleton births to Mexican mothers have experienced the slowest decrease. They are also the group that has the highest percentage of singletons. Among births to US-born Mexicans, 97.6% were singletons in 2007 as compared to 98.1% in 1989. Among births to foreign-born Mexicans, the change was even less significant, dropping only slightly from 98.2% in 1989 to 98.1% in 2007. Overall, though multiple births have been on the rise, they still account for a very small portion of US total births in 2007. Thus the analyses that follow focus on singleton births only.

TRENDS IN BIRTHWEIGHT

Figure 4.3 shows mean birthweight for singleton births by race/ethnicity and nativity in the US from 1989 to 2007. A clear trend of decreasing birthweight can be observed across almost all race/ethnic and nativity groups. To facilitate understanding and comparison of these trends, especially in regard to the magnitude, a linear trend equation is estimated and added alongside each of the observed birthweight trend lines in the graphs.

At an annual rate of 4.4 grams of decrease, US-born white mothers lead the trend for birthweight decline. Both US-born and foreign-born blacks, on the other hand, experienced the slowest decrease. In fact, birthweight for both groups remained pretty constant or even slightly increased until 2000, before seeing a drop in more recent years. Despite these trends, infants born to US-born blacks continue to have by far the lowest mean birthweight in 2007 (3,082g). At the same time, foreign-born and US-born white women continue to have the highest mean birthweight (3,375g and 3,355g, respectively).

Figure 4.3 also suggests that the decreasing birthweight trends are more pronounced among births to US-born mothers than births to foreign-born mothers. For example, mean birthweight for infants of US-born Asian and Pacific Islander (API) mothers was 3,283 grams in 1989 but dropped to 3,221 grams in 2007, an average decline of 3.5 grams per year. The decreasing rate of mean birthweight for infants of foreign-born API mothers has been much slower, at 2.5 grams per year.

Figures 4.4-4.6 look at the rates of infants at the lower and the higher end of the birthweight distribution, who have higher risk for infant mortality and adverse health outcomes. Figure 4.4 shows trends in low birthweight rates and Figure 4.5 shows very low birthweight trends for singletons by race/ethnicity/nativity. Consistent with the trends observed for decreasing mean birthweight, both the low birthweight rates and the very low birthweight rates have risen among births to almost all groups of US-born and foreign-born mothers.

As shown in Figure 4.4, the rising trends for the low birthweight rate are more pronounced among births to US-born mothers than births to foreign-born mothers. For example, low birthweight rates have been rising at 0.58, 0.39 and 0.33 per one thousand on average each year for US-born APIs, US-born whites and US-born Mexicans, respectively. Increases have been slower for their foreign-born counterparts, at 0.41 per thousand for foreign-born APIs, 0.08 per thousand for foreign-born whites and 0.33 per thousand each year for foreign-born Mexicans. Despite these changes, in 2007, the highest rate of low birthweight continues to be among births to US-born black women, at 95.7 per thousand and the lowest among births to foreign-born white and foreign-born Mexican mothers, at 36.5 and 40.6 per thousand, respectively.

Similar patterns are seen in Figure 4.5 for the very low birthweight rates. Infants born to US-born APIs experienced the fastest growth in the very low birthweight rate, increasing at about 0.2 per thousand each year. The increasing rates for other US-born groups are around 0.1 per thousand per year. Again, though, the highest rate for very low birthweight is among births to US-born black women, at 27.1 per thousand, in 2007. In contrast, the rates of growth in very low birthweight rates are much slower for infants to foreign-born mothers, with none exceeding 0.1 per thousand per year. Noticeably, however, the very low birthweight rates among infants to foreign-born black mothers and to foreign-born white mothers dropped only slightly in 2007 as compared to 1989. In

2007, as was in 1989, infants of foreign-born white mothers and foreign-born Mexican mothers have the lowest very-low-birthweight rates.

Contrary to the increasing trend of infants born with lower birthweight, the proportion of Infants with higher birthweight has been decreasing. Figure 4.6 plots the trends of change in the rates of singletons born at 4, 500 grams or higher for births to US-born mothers and to foreign-born mothers, by race/ethnicity. Almost all the race/ethnic groups have seen a drop in the proportion of heavy birthweight infants. This trend is most pronounced among singletons born to US-born white mothers; about 20 out of 1,000 singletons to US-born white mothers had birthweight of 4,500 grams or higher in 1989, but that rate dropped to 12 in 2007. The group that has the slowest decrease are infants born to US-born black mothers, although they still have the fewest births on the heaviest end in 2007 (5 per thousand). Decreases in births greater than 4,500 grams have also occurred among most groups of foreign-born mothers as well.

TRENDS IN GESTATIONAL AGE AND RATES OF LGA AND SGA

Because of the close connection between birthweight and gestational age, analyses of birthweight trends are not complete without the examination of changes in gestation as well. In this section, I report trends in length of gestation and two gestational-age-specific birthweight measures, that is, the rate of small-for-gestational-age (SGA) and the rate of large-for-gestational-age (LGA) infants. Again, the analyses focus only on singleton births in the United States from 1989 to 2007.

As noted above, a significant percentage of birth records has imputed values on gestational age. A comparison of the trends over time by race/ethnicity/nativity including and excluding records with and without the imputed data, however, suggests very little difference and thus the results using imputed data are shown here.

Figure 4.7 shows that mean gestational age for all race/ethnic/nativity groups has dropped since 1989, although the rate of change is generally faster among births to US-born mothers in comparison to births to foreign-born mothers. Births to US-born whites experienced the sharpest decrease, with mean gestational age dropping from 39.5 to 38.8 weeks between 1989 and 2007. In comparison, mean gestational age dropped from 39.4 to 38.9 weeks for infants born to foreign-born whites. Consistent with their overall lowest mean birthweight, US-born black women continue to have the lowest mean gestational length in 2007, at 38.1 weeks.

When birthweight is examined in the context of gestation, however, time trends are not as clear. Figure 4.8 shows the trend of the percentage of SGA from 1989 to 2007. Neither an increase nor a decreasing time trend can be clearly observed visually for most race/ethnic/nativity groups and the R-squared of the linear trend lines are generally very low (under 0.1). This indicates a general lack of linear change during the period. For groups that have relatively high R-squared values, namely US-born other Hispanics (0.6), foreign-born whites (0.5) and foreign-born APIs (0.4), the rate of change is slow, generally under 0.03 percentage points per year. As is also apparent from Figure 4.8, US-born black women have consistently had the highest level of SGA infants over the years, at about 16 percent each year.

Figure 4.9 tells a different story about percentage LGA singletons. A clear decreasing trend can be observed for most race/ethnic groups, especially in more recent years, and there has not been much variation in the rate of change across race/ethnic groups. Visually, the trend lines look almost parallel for most groups, although births to US-born mothers are again in the lead for LGA decrease. The rate of LGA singletons to US-born mothers dropped from 12.7 percent in 1989 to 10.6 percent in 2007, at an average of a 0.1 percentage point drop per year.

CONCLUSION

Important changes in birthweight have taken place in the US between 1989 and 2007. While the total number of births in the US has been more or less constant over the past two decades or so, the percentage of singletons has decreased. However, there are also clearly decreasing birthweight trends among singleton births. Thus, birthweight distribution is shifting to the lower end not only because of the increase in the proportion of multiple births but also due to the decreasing trend of birthweight among singletons.

This decreasing trend is not shared equally between infants born to US-born and foreign-born mothers. Mostly, singletons born to US-born white mothers have been leading the trend, being the largest group with regard to total number of births and experiencing the fastest change in birthweight and gestational age over the years. On the other hand, infants of US-born black mothers often saw the least change during this period, although they remain the group with the lowest mean birthweight, the highest low birthweight rate and the highest very-low-birthweight rate.

The birthweight and gestational age trends discussed in this chapter, both overall and by race/ethnicity/nativity, are complex and interesting, particularly in the context of rapid decreases in infant mortality in recent years (MacDorman and Mathews 2008). The descriptive results presented here, while important in and of themselves, set the stage and provide insights into the analyses for the next chapter, which explores reasons behind the recent birthweight trends in the US.

CHAPTER 5: EXPLAINING TRENDS IN U.S. BIRTHWEIGHT 1989-2007

In this chapter, I analyze U.S. trends in birthweight in relation to trends in maternal socioeconomic and demographic factors, behavioral and health factors, and health care and medical factors. I first show changes in the birthweight covariates in comparison tables that examine 1989, the beginning year of my trend analysis, and 2007, the end year for the analysis. I then report mean birthweight for these covariates in 1989 and 2007 to demonstrate changes in the bi-variate relationship between birthweight and its covariates. Lastly, I analyze the extent to which changes in these covariates affected birthweight trends between 1989 and 2007 in the US, using a series of regression models. The results for both the descriptive tables and the regression analyses are reported for all mothers, as well as for US-born non-Hispanic white mothers, US-born non-Hispanic black mothers, US-born Mexican Origin mothers and foreign-born Mexican Origin mothers.

DATA AND METHOD

Data for this chapter come from vital statistics as recorded on U.S. standard birth certificates during the period from 1989 to 2007. The analyses in this chapter will again only focus on singleton births. In addition, race, ethnicity and nativity are combined and only the four major race/ethnic/nativity groups in the US are included, namely, US-born non-Hispanic white mothers, US-born non-Hispanic black mothers, US-born Mexican Origin mothers and foreign-born Mexican Origin mothers. Births among the four groups account for the majority (about 85%) of total births in the US during 1989-2007. The exclusion of births among the rest of the race/ethnic/nativity groups is unlikely to have a major effect on the results due to their small proportion. On the other hand, focusing on the major groups greatly simplifies the analyses and the interpretation because of the size of the groups and the relative homogeneity among mothers within each group.

Descriptive analyses are first used to understand mothers' characteristics and whether and how these characteristics have changed between 1989 and 2007. The descriptive table of mean birthweight for mothers with different characteristics is very helpful in understanding the bi-variate relationship between birthweight and mothers characteristics.

Lastly, multivariate regressions are used to determine whether and how compositional changes in mothers' characteristics affect birthweight trends. Six regression models are first estimated for all births to US-born mothers to evaluate the effect of birthweight correlates on the overall trend of birthweight. Baby's sex is used as a control variable in all models. Baseline models only include one major predictor variable, "year when the birth occurred", as the trend variable. Maternal socioeconomic and demographic variables, including race/ethnicity, are added to the second model and maternal health and behaviors to the third. With the addition of health care and medical intervention variables, the fourth model includes all three sets of maternal characteristics, health and medical variables. Gestation is then added to the fifth model. If changes in any set of these factors contribute to the downward trend of the birthweight distribution, the addition of the factors will reduce the effect of the trend variable. Otherwise, the trend effect will remain unchanged or even enlarged.

The same five regression models are then analyzed for each of the three major race/ethnic groups in the United States, whites, blacks and Hispanics. The main effects and interaction effects of the predictor variables help us understand whether and how they affect the birthweight distribution differently among these race/ethnic groups.

MATERNAL CHARACTERISTICS, 1989 AND 2007

Table 5.1 compares the characteristics of infants/mothers in 1989 and 2007. All data, including those with missing values, are used to calculate the percentages. In general, the percentage of missing values is lower in 2007 than in 1989 and, for many variables, foreign-born Mexicans have the most missing values and US-born NH whites have the fewest among the four groups. Both the years of 1989 and 2007 have good data on mothers' socioeconomic and demographic characteristics, with relatively few missing values. Data on tobacco use and weight gain, however, are problematic, especially in 1989 and for the foreign-born Mexican mothers. About 70% of the data for foreign-born Mexicans and 27% for all mothers in 1989 on these two variables are missing. One reason for the high number of missing values is that questions on tobacco use and weight gain were not on the U.S. birth certificate in 1989 in some states, or some parts of the states, including New York, California and Texas. This is also part of the reason for relatively high missing values for maternal health factors and medical factors, although the percentage missing is at a much reduced level for maternal hypertension and diabetes, prenatal care, induction and cesarean variables in 2007 compared to 1989.

To better understand changes in the composition of meaningful categories of all the variables, Table 5.2 reports each percentage calculated after excluding records with any missing value. For most variables, the pattern of change is similar across the race/ethnicity/nativity groups. Thus, I will focus on changes for the population as a whole and will only discuss trends for specific race/ethnicity/nativity groups when there is a meaningful difference.

There was very little change in infants' sex and the birth order composition between 1989 and 2007. Mother's mean age at birth, on the other hand, increased from 1989 to 2007. Proportions of mothers both under 17 and between 17 and 34 years of age have decreased, while the proportion of mothers 35 and older increased from 8% to almost 13% over the time period. To capture the interaction between mother's age and birth order, the parity variable is constructed. Third or higher order births to women under 25 years of age or fourth or higher order births to women under 30 are defined as high parity. First births to women 30 and older are put in a separate category and all the other births are defined as low parity. From 1989 to 2007, there was a slight decrease in high parity births and a relatively larger increase in women having a first birth at ages 35 and above. As a result, the percentage of low parity births decreased between 1989 and 2007.

Women's education greatly improved over the years. The percentage of mothers who have less than 12 years of schooling dropped for all race/ethnicity/nativity groups, although the overall percentage has actually increased slightly due to the rapid increase in the composition of foreign-born Mexican mothers, who have by far the highest percentage in this category (still as high as 61.8% in 2007). The percentage of mothers who are high school graduates or equivalent dropped greatly for non-Hispanic whites (from 40.8% to 26.5%), followed by non-Hispanic blacks and US-born Mexicans. In turn, the percentage of mothers who have some college or an associate's degree or higher increased significantly among the three groups. The improvement in education for foreign-born Mexicans, on the other hand, is due to not only the increase in mothers with some college or more, but also due to an increase in those having a high school degree or equivalent. Also in 2007, infants are more likely to be born to unmarried mothers compared to 1989. Non-marital births comprised about 40% of all births in 2007, as compared to just 26.6% in 1989. Non-marital births were also much more common among blacks (71.6%) than among whites (24.4%) in 2007, with the Mexican Origin groups falling in-between.

Three behavioral and health factors are included in the analysis: weight gain, tobacco use and a variable indicating that women suffered from either diabetes or hypertension during pregnancy. Fewer women gained 25-35 pounds during pregnancy in 2007 than in 1989; the percentage decreased from 43% to 35.1%. This is the result mainly of a rise in the percentage of women who have gained 35 pounds or more during pregnancy and to a lesser extent, an increase in women gaining less than 25 pounds. These trends, however, are less pronounced among foreign-born Mexican mothers than the other three race/ethnicity/nativity groups. The percentage of women who smoked during pregnancy decreased by almost half between 1989 and 2007, from 20.7% to 11.4%. Diabetes and hypertension (both gestational and chronic) are combined as one variable due to their close connection to each other. Mothers diagnosed with neither diabetes or hypertension have decreased (from 94.2 to 91.4) while those with either or both of the conditions increased between 1989 and 2007.

The prenatal care, induction, and cesarean variables constitute the health care and medical factors in the analysis. The Kotelchuck Index (Kotelchuck 1994) of prenatal care utilization is calculated and used to measure adequacy of prenatal care. While the percentage of women with inadequate and intermediate care dropped between 1989 and 2007 for all women and for each of the race/ethnicity/nativity groups, the percentage of mothers with adequate prenatal care increased for all groups except for non-Hispanic white mothers. A notable trend is that the percentage of mothers with more than adequate prenatal care increased for all groups, possibly indicating a rise in the percentage of problematic pregnancies between 1989 and 2007. The induction rate more than doubled from 1989 to 2007, and now constitutes more than 20% of all deliveries for all groups except foreign-born Mexican women. Finally, the cesarean rate increased by almost 8 percentage points between 1989 and 2007. As of 2007, 30 percent of all deliveries were by cesarean section, with the rate highest for black women (31.8%) and the lowest rate among foreign-born Mexican women (27.7%).

MEAN BIRTHWEIGHT BY MOTHER'S CHARACTERISTICS, 1989 AND 2007

In this section, I compare infants' mean birthweight by mothers' characteristics between 1989 and 2007. This enables the understanding of the bi-variate relationship between mothers' characteristics and mean birthweight, and whether the relationship has changed from 1989 to 2007.

Table 5.3 includes all singletons born in 1989 and 2007 in the United States whose birthweight and gestational age are known. One striking fact from Table 5.3 is that the reduction in mean birthweight from 1989 to 2007 occurred across all race/ethnic groups regardless of mothers' socioeconomic and demographic, behavioral and health, or health care and medical factors captured on the birth certificate and listed in the table. It is clear that no single group or change in one factor has contributed to the overall decreasing trend in birthweight.

Table 5.3 also suggests that in 2007, male infants, infants born to mothers who have disadvantaged socioeconomic status, who are of high parity, who have lower weight gain or consume tobacco during pregnancy, who have hypertension, or who lack prenatal care have lower mean birthweight. On the other hand, infants born to mothers who have diabetes or have induced labor weigh more at birth than those who do not. These patterns are not very different from 1989. However, in almost all cases, the differences in mean birthweight across different groups have lessened. For example, infants of married mothers were on average 236 grams heavier than infants of unmarried mothers in 1989 but the difference reduces considerably to 162 grams in 2007. In both years, mothers who receive adequate plus prenatal care give birth to the heaviest infants among all the prenatal care groups while mothers who get inadequate prenatal care have babies of the lowest birthweight. However, the difference in birthweight between them decreased from 248 grams to 174 grams.

Only in the case of one variable do we see an increase in differences between the groups with the highest and the lowest birthweight, that is, the diabetes and hypertension variable. Mothers who have diabetes only have the heaviest babies while mothers who have hypertension only have babies of the lowest birthweight. The difference between them is 283 grams in 1989, but increased to 344 grams in 2007. However, because of the high percentage of missing values in 1989, it is hard to tell what this increase implies.

REGRESSION MODELS ON CONTINUOUS BIRTHWEIGHT TRENDS FOR ALL U.S. INFANTS FROM 1989 TO 2007

Table 5.4.1 depicts the results of the OLS regression models on continuous birthweight for all infants born between 1989 and 2007. Model 1 is the base model, in which the only predictors are sex of infant and the year variable depicting trends. Race variables are added in Model 2. Mothers' socioeconomic and demographic, behavioral and health, and health care and medical factors are then added in blocks in Model 3 through Model 5. Model 6 is the final model, in which gestational age is added in addition to all the variables in the previous models.

Model 1 suggests that controlling for infant's sex, birthweight dropped by an average of 3.73 grams every year from 1989 to 2007. In Model 2, race of the mother is added. It has been well documented that infants born to non-Hispanic black mothers have a much higher low-birthweight rate than non-Hispanic white mothers. Yet it is still striking that their birthweight is on average 290 grams lower than non-Hispanic whites over the past two decades. Controlling for race, however, does not change the direction or reduce the magnitude of the yearly trends. In fact, the trend variable increases slightly from 3.73 in Model 1 to 3.80 in Model 2.

In Model 3, socioeconomic and demographic variables including age, birth order, parity, education and marital status are added. The results are generally consistent with previous studies. Infants born to women age 25 to 34 have higher birthweight than those born to younger or older mothers. First-born children are lighter than second or higher order birth and high parity results in lower birthweight than low parity. Infants born to mothers without high school degrees have the lowest birthweight and in fact, the higher the mother's education, the heavier the infant's birthweight. Births to married mothers are heavier than those to unmarried mothers. But again, controlling for these socioeconomic and demographic variables does not change the direction or reduce the magnitude of the overall birthweight trend. In fact, the trend becomes more pronounced in Model 3, with the absolute value increasing from 3.8 from the previous model to 4.22 in Model 3. This indicates that had socioeconomic and demographic variables stayed the same during the past two decades, birthweight would have been even lower in 2007 than observed.

Mothers' health and behavioral factors are added in Model 4. As expected, infants born to mothers with diabetes but not hypertension have the highest birthweight while those born to mothers with hypertension only have the lowest birthweight, about 238 grams lower than mothers who have neither diabetes nor hypertension. The higher the weight gain of mothers during pregnancy, the higher the infant's birthweight. And infants born to mothers who smoke during pregnancy weigh 217 grams less, on average, than those of mothers who do not smoke. However, the addition of the health and behavioral variables in the model still does not explain the lowering birthweight trend. Indeed, the trend becomes even more pronounced in Model 4, at -4.7 grams per year.

Model 5 adds health and medical intervention variables, including prenatal care, induction and cesarean section. Net of the socioeconomic and demographic, and health and behavioral factors included in the model, infants of mothers who receive more than adequate care have the lowest birthweight, 187 grams lower than those whose mothers receive adequate care. Infants of mothers who experience induction or Cesarean section are on average heavier. The inclusion of medical and health care factors in Model 5 only bring down the birthweight trend by a fraction: it decreases from -4.7 in Model 4 to -4.5 in Model 5, indicating that changes in health care and medical variables do not contribute much to the lowering birthweight trend.

Finally, Model 6 includes all the variables, including gestational age. A week's increase in gestational age is associated with a 112 grams increase in birthweight. As the most proximate predictor of birthweight, the trends in shortening gestational age clearly plays an important role in explaining trends in birthweight. Controlling for gestational age, as well as the variables included in previous models, birthweight decreases at an average of 1.57 grams per year in the final model. Thus, reduced average gestational age between 1989 and 2007 accounts for a large share of the overall reduction in birth weight across this time period.

REGRESSION MODELS OF BIRTHWEIGHT BY RACE/ETHNICITY/NATIVITY, 1989 TO 2007

Tables 5.4.2 to 5.4.5 report the OLS regression results of birthweight for NH whites, NH blacks, US-born Hispanics and foreign born Hispanics, respectively. Consistent with the descriptive analyses in the previous chapter, all four race groups experienced a birthweight decrease from 1989 to 2007, as suggested by the negative coefficient for the year trend variable in the base models. The trend is most pronounced among NH whites, with an average of a 4.4 gram drop each year, and least among NH blacks, with an average 1.8 gram decline per year. In general, the associations of the mothers' various characteristics with mean birthweight are similar to the overall model, except that the magnitudes are a bit different. For example, in the models for NH whites, NH blacks and US-born Mexicans, mothers' education is an important predictor of infants' birthweight. Even in the final full model, mothers with bachelor's or higher degrees have babies who weigh 44 grams (US-born Mexicans) to 85 grams (US-born whites) more than those without high school degrees. For foreign-born Mexicans, however, the birthweight for infants of mothers with different education backgrounds is only a few grams different. In fact, the directions are reversed in the final model for foreign-born Mexicans: infants whose mothers have higher education actually weigh less at birth, on average, than those without high school diplomas.

There are also some differences across race groups when it comes to the role of different variables in explaining the lowering birthweight trends. Models for NH whites and US-born Mexicans are most similar to the overall model: socioeconomic and demographic, and health and behavioral factors not only fail to explain the birthweight trends but their addition make the trends more pronounced in the models. Medical and health factors also play a very limited role in explaining birthweight trends. For NH blacks, none of the three groups of mothers' characteristics explain the trends in birthweight. Had the maternal characteristics stayed the same, birthweight would have been even lower for NH blacks in 2007. Models for foreign-born Mexicans are the most different from the rest of the race/ethnic groups. While the inclusion of socioeconomic and demographic variables does increase the absolute value of the trend variable, the introduction of health and behavioral, and medical and health care variables help to explain away some of the lowering birthweight trend. After controlling for all the mothers' characteristics, the year coefficient changes from -3.26 in the base model to -2.7 in Model 4. Finally, in the models for all race groups, gestational age plays the most important role. And in the final models, birthweight drops by 1.2 (US-born Mexicans) to

1.7 grams (for foreign-born Mexicans) per year after including all the variables included in the analyses.

Clearly, then, lower average gestational ages for all race/ethnic/nativity groups in 2007 compared to 1989 is the most prominent factor responsible for reductions in mean birthweight for all groups over this time period.

CONCLUSION

The comparison of mother's characteristics between 1989 and 2007 at the beginning of the chapter suggests that changes in some of these factors may have contributed to the lowering birthweight trend, such as the increase of infants born to unmarried mothers, the increase of first births to women 35 and over, the increase of mothers with hypertension and the increases in induction and Cesarean section births. However, there have also been changes that are associated with increases in birthweight, such as the improvement in mothers' education, the decrease of tobacco use during pregnancy and the increase in mothers receiving adequate prenatal care.

Looking at the mean birthweight by mothers' characteristics helps us understand the bi-variate relationship between mean birthweight and its covariates and, importantly, whether these relationships have changed over time. The comparison between 1989 and 2007 suggests that mean birthweight has decreased for almost all the sub-population groups examined but have, in most cases, decreased more for groups that used to have higher mean birthweight.

The regression models for birthweight trends for all infants and for the four race/ethnic groups are shown toward the end of this chapter. The models start with a base model depicting trends; and subsequent models add sets of covariates. In the models for all infants and for the race/ethnic/nativity groups, changes in socioeconomic and demographic factors as a group do not explain the lowering birthweight trend. In fact, birthweight would have been even lower had these factors stay the same. Health and behavioral, and health care and medical factors, on the other hand, explain part of the trends for some race groups but not for others. Clearly, gestational age is the most important factor in explaining the lowering trends of birthweight in the overall models and in the models for each of the race/ethnic/nativity groups. However, the birthweight trend remains significant in the final models, suggesting factors other than changes in mothers' characteristics and gestational age have also played a role. When comparing models among the four race/ethnic groups, foreign-born Mexicans are the most different from the others. For example, the association of mothers' education with infants' birthweight is less strong among foreign-born Mexicans and health and behavioral factors, and health care and medical factors play a more important role in explaining the birthweight trend than for other race/ethnic groups.

In all, the most notable finding for all infants and for each race/ethnic/nativity group is that lower gestational age in 2007 in comparison to 1989 is in large part responsible for lower mean birthweight in 2007 compared to 1989. To determine the percentage contribution of each of the covariates, including gestational age, the next chapter employs a regression decomposition method to decompose the birthweight changes between 1989 and 2007 into changes due to composition (endowment change) and changes due to the effects of covariates (coefficient change).

CHAPTER 6: REGRESSION DECOMPOSITION OF BIRTHWEIGHT TRENDS, 1989 AND 2007

As we learned from the previous chapter, at least part of the birthweight decline from 1989 to 2007 in the US is attributable to the compositional change in mother's characteristics, especially in gestational age. In this chapter, I decompose the difference in birthweight between 1989 and 2007, the beginning and the end year of the period, into two parts, one due to the compositional changes in the covariates and the other due to the change in the effects of the covariates on birthweight. Furthermore, since this dissertation is mainly interested in how compositional changes have affected birthweight trends, the discussion in this chapter focuses on the part that is due to compositional changes and the percentage contribution of the each of the variables in detail. Decomposition results will be reported first for all singleton births and then by race/ethnicity/nativity.

DATA AND METHODS

Data used in this chapter only include singleton births that occurred in 1989, the beginning year, and 2007, the end year of the analysis period. As in the previous chapter, records with missing values on birthweight and gestational age are excluded. And again, only the four major race/ethnic/nativity groups are included, that is, US-born whites, US-born blacks, US-born Mexicans and foreign-born Mexicans. The final data have 3,198,194 observations for 1989 and 3,313,468 observations for 2007.

Since the outcome variable is continuous birthweight, a decomposition method for linear regression models is used. Although many researchers have contributed to the development of the regression decomposition method and multivariate decomposition has been used in demography and social research for many years (Kitagawa 1955; Coleman et al. 1972; Powers and Yun 2010), this technique became more widely known after its application by Oaxaca (1973) and Blinder (1973) in the econometric literature. And the method is also known by the name of Oaxaca-Blinder, Oaxaca, or Blinder-Oaxaca decomposition. There are variations of the method and it has been extended to nonlinear models, for example, for hazard models (Powers and Yun 2009).

To do regression decomposition, one starts by conducting regressions on the outcome variable for each of the two groups, or two years in question. For this dissertation, the two groups/years are i=1989, 2007. Assuming there is a linear relationship between infants' birthweight (y_i) and a number (K) of mother's characteristics (x_{ik}), the OLS regression is expressed as:

$$y_{i=}a_i + \sum_{k=1}^{K} b_{ik}x_{ik} + \epsilon_i$$

And the mean birthweight of each of the groups is:

$$\bar{y}_i = \alpha_i + \sum_{k=1}^{K} \beta_{ik}\bar{x}_{ik}$$

where x_{ik} is the mean of the kth independent variable in the ith group, α_i is the intercept of group i and β_{ik} is the parameter estimate of the kth variable for the ith group.

Then the birthweight difference between the two years, the higher and the lower in its order, can be decomposed into the following three components:

$$\bar{y}_{1989} - \bar{y}_{2007} = (\alpha_{1989} - \alpha_{2007}) + \sum_{k=1}^{k} \bar{x}_{k2007}\,(\beta_{k1989} - \beta_{k2007})$$
$$+ \sum_{k=1}^{k} \beta_{k1989}(\bar{x}_{k1989} - \bar{x}_{k2007})$$

1) the difference in intercepts between the higher (1989) and the lower (2007) birthweight; 2) the difference in slopes, weighted by the corresponding mean values of the independent variables in 2007, the year with lower mean birthweight; and 3) the difference in the mean values of the independent variables, weighted by the mean corresponding slopes in 1989, the year with the higher mean birthweight. The first two items are the component of the difference due to slope changes, or changes in the effect of the independent variables (called C for coefficients). The second term is the component of the difference due to compositional changes of the independent variables (called E for endowment). Each component can be further analyzed to determine the percent contribution of all the independent variables. The results of the decomposition are discussed in the next section.

DECOMPOSITION FOR ALL SINGLETON BIRTHS

Table 6.1 shows the results for the regression decomposition of the birthweight difference between 1989 and 2007 for all singletons. Mean birthweight was 3,373 grams in 1989 and 3,303 grams in 2007. The 70 grams difference is decomposed into two components, the endowment (E) in column 2 and the coefficient (C) in column 4. In total, 28 grams, or 40.4% of the change between 1989 and 2007 was due to the endowment component (compositional change) while 42 grams, or 59.6%, was due to the coefficient component, or changes in the relationship between birthweight and its covariates.

Column 3 shows the percentage contribution of each of the mother's characteristics to the endowment component. Noticeably, changes in the composition of mothers' race/ethnicity/nativity, age, birth order, education, health and behavioral conditions, induction and cesarean section have all contributed negatively to the birthweight difference. This suggests that had these maternal characteristics been the same in 2007 as in 1989, the birthweight difference would have been even larger. On the other hand, changes in marital status and gestational age are the major positive contributors. Most strikingly, changes in gestational age contributed to 215.8% of the endowment component.

The biggest contributor to the coefficient change is the intercept, which reflects factors unexplained by the current model. 489 grams, or 1174.7% of the coefficient change, is due to factors not accounted for by the regression model. This is almost cancelled out by changes in the gestation coefficient, which contributed negatively 464 grams, or 1114.6% to the coefficient change.

DECOMPOSITION BY RACE/ETHNICITY/NATIVITY

Tables 6.2.1 to 6.2.4 report the regression decomposition results for US-born whites, US-born blacks, US-born Mexicans and foreign-born Mexicans, respectively.

US-born whites have the biggest difference in mean birthweight between 1989 and 2007, at 79 grams. 38 grams, or 48.6% of the difference, is due to endowment and 41 grams, or 51.4%, is due to coefficient change. Similar to the overall pattern described above, marital status and gestational age in particular are the biggest contributors to the birthweight difference due to compositional change, accounting for 16.9% and 186%, respectively.

US-born blacks have the smallest difference in mean birthweight between 1989 and 2007. They are also the most different from other groups. Almost all the difference is due to coefficient change. In fact, the contribution of compositional change is negative 5 grams, meaning the birthweight difference would have been 5 grams more had all the mothers' characteristics been the same. But similar to US-born whites, marital status and gestational age are the biggest negative contributors to the negative difference, or in other words, the biggest positive contributors to the birthweight difference between the two years. Mothers' change in such factors as education, weight gain, smoking, and prenatal care have contributed greatly to the negative difference, or to narrowing the difference between 1989 and 2007.

US-born Mexicans and foreign-born Mexicans have a similar difference in mean birthweight between 1989 and 2007, 60 grams and 57 grams, respectively. The percentage contribution patterns for the variables are in general similar, too. Compared to whites, the endowment component plays a slightly bigger role, accounting for 59.2% (US-born Mexicans) and 55.2% (foreign-born Mexicans) of the mean birthweight difference. Similar to whites, gestational age contributes by far the most to changes due to compositional change and so does marital status. Interestingly, smoking accounts for 56.1% (for US-born Mexicans) and 89% (for foreign-born Mexicans) of the difference. A closer look (see appendix table A), however, revealed that it is due to the compositional change of the missing records on smoking. This may suggest that smoking status is simply better recorded in 2007. Also similar to whites, most of the other variables contributed negatively. However, education plays a lesser role in narrowing the birthweight difference for US-born Mexicans (-12.5%) than for whites (-22.8%). And for foreign-born Mexicans, percentage contribution for education is positive, albeit very small (2.3%), suggesting again that the role of education for foreign-born Mexicans is very small.

CONCLUSION

Results from the regression decomposition in this chapter suggest that the birthweight difference between 1989 and 2007 is attributable to both compositional changes and coefficient changes of the independent variables for all births and for births to US-born whites, US-born Mexicans and foreign-born Mexicans. For US-born blacks, coefficient changes are solely responsible for the birthweight change.

When evaluating compositional changes in detail, the shortening of gestational age is the biggest contributor to the birthweight difference for all groups examined, followed by the decreasing rate of married mothers. Changes in most of the other mothers' characteristics mediated the trends. In other words, had it not been for the improvement of mothers' education, health and behaviors, for example, the reduction of smoking, the difference in birthweight would have been even larger. While education is one of the biggest mediators for all groups and for other race/ethnic/nativity groups in narrowing the birthweight difference, its role for foreign-born Mexicans is minimal.

CHAPTER 7: DISCUSSIONS AND IMPLICATIONS

From 1989 to 2007, birthweight distribution has shifted to the lower end in the U.S. The proportion of low-birthweight infants (less than 2,500g) has increased while the proportion of heavier-birthweight infants has decreased (more than 4,500 g), and there has been a slow but steady decrease of mean birthweight. This dissertation provides thorough and detailed descriptions of the lowering birthweight trend and examines the reasons behind the trends from a demographic perspective. In addition to the overall trends, birthweight trends for the four major race/ethnicity/nativity groups, namely US-born whites, US-born blacks, US-born Mexicans and foreign-born Mexicans, are also discussed.

KEY FINDINGS

Data used in this study suggest that the lowering birthweight trend in the U.S between 1989 and 2007 is the result of both the rapid increase in multiple births, who, on average, have lower birthweight than singleton births, and the decrease in birthweight among singletons. This study focuses on singleton births because they are still the vast majority and account for more than 96% of all births in 2007. While previous research has documented the lowering birthweight trend, the focus is usually on one birthweight measure, for example, low-birthweight rate, or on the general population (Martin et al. 2009; Donahue et al. 2010). Little is known as to whether the lowering trend occurred only among portions of the birthweight spectrum or whether the trend is shared by all demographic groups.

The current study uses multiple birthweight measures to examine birthweight trends among all major race/ethnicity/nativity groups. The trends of four sets of birthweight measures are described, namely, mean birthweight, low-birthweight rate and very-low-birthweight rate, rate of infants over 4,500 grams, and SGA rate and LGA rate. From 1989 through 2007 for all infants in the U.S., a clear and steady trend of decrease is observed for mean birthweight, rate of infants over 4,500 grams and LGA rate, accompanied by the increase of low-birthweight rate and very-low-birthweight rate. SGA rate is the only measure that has seen a lack of change. Trends in these birthweight measures point to a total shift of birthweight distribution to the lower end.

The decreasing birthweight trends occurred to all race/ethnicity/nativity groups, although the extent of change varies. In general, foreign-born mothers have experienced a much lower rate of change. In fact, the lowering birthweight trends would have been more pronounced had there not been a steady increase in births to foreign-born mothers. US-born white mothers lead the decreasing birthweight trends on all measures. This deserves our special research attention not only because US-born white mothers have the most births but they have also been the group that has more favorable birthweight, especially compared to black mothers. The group with the least change between 1989 and 2007 is US-born black mothers, although they still have by far the lowest mean birthweight, the highest low-birthweight and very-low-birthweight rates.

Previous literature suggests that birthweight outcomes are affected by a set of maternal social and biological factors. This study examines three groups of determinants for birthweight, namely, maternal socio-demographic factors, maternal behavioral and health factors, and health care and medical intervention factors. Bi-variate descriptive tables between birthweight and these maternal factors suggest that mean birthweight has decreased for almost all sub-population groups and that the birthweight differences among these groups are, in most cases, narrowed. Regression analyses suggest that changes in the maternal characteristics cannot fully explain the lowering birthweight trend, although part of the trend is attributable to shortened gestational age. This holds true across all race/ethnicity/nativity groups.

To further understand the role of each of the predictors, the birthweight difference between 1989 and 2007 is decomposed into two components using a multiple regression decomposition method. One is the trends in maternal factors, that is, endowment changes, and the other is the change in the effects of these factors on birthweight, that is, coefficient changes. One previous research (Young et al. 2006) has examined the association of age and parity distributions with trends in birthweight and found that change in the effect of age-parity on birthweight plays a more important role in the lowering birthweight trend than the trend in age-parity distribution. This dissertation extends the previous study by using a regression decomposition method to determine the percentage contribution of multiple predictor variables for birthweight at one time.

Results of the regression decomposition reveal that for the overall trend, 40.4% of the birthweight difference between 1989 and 2007 is due to endowment changes and 59.6% due to coefficient changes. When the endowment component is examined in detail, changes in most of the maternal factors, except for marital status, are associated with increased birthweight. Not surprisingly, gestational age is the biggest contributor to the endowment change component, contributing more than 100% to the decreasing mean birthweight, suggesting that had it not been changes in the composition of race/ethnicity/nativity, mother's age, birth order, the improvement of education and health and behavioral conditions, birthweight would have been even lower in 2007 than in 1989. These patterns are generally consistent across race/ethnicity/nativity groups except for US-born blacks. Birthweight difference between 1989 and 2007 is the smallest among US-born blacks and all the difference is due to coefficient change. But similar to other race/ethnicity/nativity groups, gestational age plays the dominant role in the endowment component. Among all the race/ethnicity/nativity groups except for foreign-born Mexicans, education plays a very important role in slowing the lowering birthweight trend.

The results from the current analysis are different from studies in Europe and Canada, where researchers found that the increasing birthweight trends in these countries were explained by maternal factors such as the increase in mothers' weight and height, the increasing prevalence of diabetes, the increase of average mothers' age and the decrease in cigarette smoking during pregnancy (Kramer et al. 2002; Bergmann et al. 2003; Surkan et al. 2004).

The results on birthweight trend from this study, however, are consistent with a study (Donahue et al. 2010) published during the process of the completion of this dissertation. Using US birth data from 1990 to 2005, Donahue et al. (2010) concludes that average birthweight and percent of large for gestational age births decreased for singleton term births from 1990 to 2005 and that the trends in maternal characteristics, obstetric practices and gestational age do not explain the decreasing trends in birthweight.

This dissertation concludes with results consistent with the previous research but expand existing literature in the following aspects. First, this dissertation examines multiple measures for birthweight, including measures that reflect changes on different part of the birthweight spectrum. This helps to identify the sources of change and to select outcome variables to be further studied. Almost all the measures examined in the study exhibit a downward trend, which reflects a complete shift of the birthweight distribution to the lower end. Therefore, the use of the continuous birthweight variable for further analyses in the regression models is justified. Second, this dissertation includes births at all gestational age and does not exclude pre-term babies as have done by most previous studies. The author argues that in light of the concurrent shift of birthweight and gestational age toward the lower end, it is of special importance to include pre-term infants so as to understand the overall trends in birthweight. Third and perhaps most importantly, in addition to overall birthweight trend, this dissertation examines birthweight trends among different race/ethnicity/nativity groups. As reviewed in the previous chapters, numerous studies have examined racial/ethnic differences in birthweight but little is known about the racial/ethnic difference in birthweight trends. The results from the current analyses suggest that the decrease of birthweight is fastest among non-Hispanic whites and least pronounced among non-Hispanics. Furthermore, maternal characteristics, health and behavioral factors and medical practices have affected birthweight trends differently across different race/ethnicity/nativity groups. Last, the use of multiple regression decomposition in this dissertation expands the study on birthweight trends. The decomposition quantifies the contribution of each predictor variables and helps identify the roles of the predictor variables in affecting birthweight trends.

LIMITATIONS

This dissertation includes a wide range of maternal factors that potentially impact birthweight trends. However, the inclusion of variables is limited by the availability of information from the birth data used for the analyses. Some of the important determinants for birthweight are not available from the vital statistic records. For example, mothers' weight was not asked on the birth certificate until the 2003 revision. Only limited information is available on mothers' health. And environmental and neighborhood factors cannot be obtained from the birth data.

To better understand the birthweight trend, this study uses almost two decades of data from 1989 and 2007. As with all studies that cover long periods of time, changes in the way that data are collected can potentially bias the results of the analysis. During the period under analyses, there have been two revisions of the standard birth certificate in the US, one in 1989 and the other one in 2003. Differences in the two revisions occur across years and between states that use different versions of the birth certificate in the same year.

Not surprisingly, some questions are asked on one revision but not on the other. For example, mothers' weight and height are new on the 2003 revision whereas mother's alcohol use during pregnancy, which was on the 1989 revision, was eliminated from the 2003 revision. Thus, as important as these variables are to the analysis of birthweight, they have to be excluded from the trend analyses.

For the items available on both revisions, some are asked differently between the two revisions. Years of education is included in the 1989 revision but in the 2003 revision, education is measured by grades completed or the highest degree obtained. In this dissertation, education in years (from the 1989 revision) is approximated to the corresponding categories on the 2003 revision. Similar issues also occur with mother's tobacco use and timing of prenatal care initiation. Nonetheless, sizable inconsistencies are not detected in the general trend or between data from the two revisions. However, it is unclear what impact differences between the two versions of the birth certificate have on the current study.

There is little doubt that the quality of data collection for vital statistics has improved over the years. According to NCHS, the sources of data and the procedures and tools of data collection for the vital statistics system are greatly improved over the years and in the new revision (http://www.cdc.gov/nchs/nvss/vital_certificate_revisions.htm. Accessed 22 July 2012). While it is a welcoming trend for research in general, it could affect the results of analyses using different years of data, especially over a relatively long period of time. And sometimes, the effects may be unknown. One known fact for the data used in this analysis is the reduction of missing data. The percentage of records that have missing values on variables used in this analysis have gradually gone down from 1989 to 2007 (Appendix Table B). For some variables, the changes are very significant. For example, 27.5% of the data are missing on tobacco use in 1989 compared to only 5.7% in 2007 (Table 5.1%). This issue is further complicated by the racial differences in percentage of missing data. In 1989, 69% of data are missing for foreign-born Mexicans compared to 24% Non-Hispanic whites, while in 2007, the racial differences have decreased along with the substantial reduction of missing data overall.

Missing data, especially those not missing at random, is a challenge faced by many social researchers using empirical data. Different methods have been proposed to handle the missing data, although none has stood out as a better choice than the other (Allison 2001). This study adopts a simple and straightforward approach. The descriptive analysis reports results from data both with and without missing data. In the regression analyses, missing values are put in a separate category. Data imputation is not conducted by the author. But the analyses do use imputed data provided by NCHS. Most of the imputation occurs to the gestational age variable, which is based on an established imputation method (National Center for Health Statistics 1982).

Several commonly used measures for birthweight such as the low-birthweight rate, mean birthweight, LGA and SGA are examined in this study. Each of these measures reflects a different aspect of the birthweight distribution, although only regression results on mean birthweight are reported due to the general consistencies in the results across the measures. Future studies may benefit from using new measures and methods to study changes in birthweight distribution. One such method is the relative distribution method, which provides a full comparative distributional analysis and helps identify the "origins of distributional changes within and between groups" (Handcock and Morris 1999: 1).

IMPLICATIONS

Results from this study suggest that the decreasing trend in birthweight in the US is due, in great part, to the shortening of gestational age between 1989 and 2007. However, there is large part of the trend that is not explained by standard determinants such as gestational age and other maternal factors. Research on the causes of the recent gestational age trend should shed light on the birthweight trend. Interestingly, this study does not find an association between the increase of induction or cesarean rates and the decrease of birthweight. However, one study on the relationship between cesarean delivery and gestational age finds that the increase in the preterm birth rate is primarily among cesarean sections (Bettegowda et al. 2008). Another study reviews the effect of Assisted Reproductive Technology (ART), which has been increasing in recent years, on birth outcomes and finds that ART is associated with elevated risk of low birthweight and preterm births. These findings suggest that recent trends in medical interventions and obstetric management both before and during pregnancy, and at delivery may have an impact on the lowering of birthweight directly or indirectly through gestational age.

The implications of shortened gestation and as a result, the lowered birthweight trend, for public health, however, are unclear. While the increases in preterm and low-birthweight infants are usually not desirable, they may reflect a "greater willingness on the part of obstetric providers to hazard neonatal risks of prematurity rather than fetal risks in a continuing pregnancy" (Grobman 2007: 537). Indeed, according to a recent NCHS report, the US fetal mortality rate declined from 7.49 in 1990 to 6.23 in 2003 (MacDorman and Kirmeyer 2009). In every sense, causes of recent trends in birthweight and gestational age, as well as the implications of the trends, are complicated and should be closely monitored and studied.

One implication from the results of the study is clear. Improvement in maternal socio-economic, health, and behavioral factors do play a role in mediating the lowering birthweight trend. Had it not been for the improvement of mothers' education, the reduction of smoking during pregnancy and the improvement of prenatal care, birthweight would have been even lower in 2007 than in 1989. This is especially true among non-Hispanic Blacks, who experienced the least birthweight decline in recent years.

While more research is needed to identify factors that are associated with the recent birthweight trend and its implications, continued efforts toward the improvement of women's education, reduced smoking and reproductive health care are still key to favorable birth outcomes in the United States.

Table 4.1 Total number of births by mother's birth place, Unites States, 1989-2007

	Total	USB	%	FB	%	Origin Unknown	%
1989	4,045,693	3,451,785	85.3	585,855	14.5	8,053	0.2
1990	4,162,917	3,505,024	84.2	649,906	15.6	7,987	0.2
1991	4,115,342	3,434,521	83.5	671,477	16.3	9,344	0.2
1992	4,069,428	3,366,292	82.7	694,622	17.1	8,514	0.2
1993	4,004,523	3,290,365	82.2	704,551	17.6	9,607	0.2
1994	3,956,925	3,216,426	81.3	731,975	18.5	8,524	0.2
1995	3,903,012	3,170,385	81.2	722,985	18.5	9,642	0.2
1996	3,894,874	3,138,670	80.6	746,232	19.2	9,972	0.3
1997	3,884,329	3,125,234	80.5	749,940	19.3	9,155	0.2
1998	3,945,192	3,167,022	80.3	768,014	19.5	10,156	0.3
1999	3,963,465	3,149,330	79.5	800,883	20.2	13,252	0.3
2000	4,063,823	3,180,850	78.3	870,866	21.4	12,107	0.3
2001	4,031,531	3,111,010	77.2	909,822	22.6	10,699	0.3
2002	4,027,376	3,079,443	76.5	938,794	23.3	9,139	0.2
2003	4,096,092	3,109,780	75.9	971,082	23.7	15,230	0.4
2004	4,118,907	3,103,640	75.4	998,626	24.2	16,641	0.4
2005	4,145,619	3,106,590	74.9	1,022,355	24.7	16,674	0.4
2006	4,273,225	3,191,754	74.7	1,065,869	24.9	15,602	0.4
2007	4,324,008	3,232,214	74.8	1,076,613	24.9	15,181	0.4

Table 5.1 Mothers' characteristics by nativity/race/ethnicity, 1989 and 2007 – all data included

	2007					1989				
	US NH white	**US NH black**	**US Mex**	**F Mex**	**All**	**NH white**	**NH black**	**US Mex**	**F Mex**	**All**
N	2,166,670	544,872	266,101	461,941	3,439,584	2,365,496	551,016	128,528	192,430	3,237,470
Infant's sex										
Female	48.7	49.2	48.9	48.9	48.8	48.6	49.3	49.0	49.0	48.8
Male	51.3	50.8	51.1	51.1	51.2	51.4	50.8	51.1	51.0	51.2
Socio-economic and demographic factors										
Age										
17 & Under	2.2	7.0	9.5	3.6	3.7	3.1	11.3	10.3	4.7	4.9
18-20	5.9	12.5	13.0	7.1	7.7	6.7	13.7	13.3	8.7	8.3
20-24	23.7	34.2	32.6	27.7	26.6	24.8	32.8	32.2	33.5	27.0
25-34	53.3	38.1	38.6	49.2	49.2	56.5	37.1	38.7	45.2	51.9
35 and older	15.0	8.2	6.3	12.3	12.9	8.8	5.1	5.5	7.9	8.0
Birth Order										
First	35.0	32.4	36.6	27.0	33.6	34.5	30.8	33.7	32.2	33.7
Second	29.2	24.7	26.4	27.8	28.1	31.0	26.9	27.6	25.9	29.9
Third+	34.9	41.7	36.7	44.7	37.5	34.0	41.7	38.6	41.7	35.9
Missing	0.8	1.3	0.4	0.5	0.8	0.5	0.6	0.2	0.3	0.5
Parity										
Low Parity	80.5	74.4	78.3	82.9	79.7	82.1	73.4	78.0	81.4	80.4
High Parity	11.2	22.9	18.7	13.8	14.0	11.7	24.5	19.9	16.3	14.5
First Birth and 35+	8.4	2.8	3.0	3.4	6.4	6.2	2.1	2.1	2.2	5.1
Education										
0-12th grade	11.2	23.4	30.2	61.3	21.5	13.9	28.7	36.9	68.3	19.6

Table 5.1, cont.

Hi school grad or GED	26.6	37.3	35.8	24.6	28.7	36.6	41.2	35.0	16.7	36.1
Some college	22.9	24.9	20.7	6.8	20.9	20.4	18.0	12.2	5.7	19.8
Associate D or higher	38.7	13.6	12.3	5.1	28.1	19.5	6.2	4.0	2.2	15.6
Missing	0.5	0.9	1.0	2.1	0.8	9.6	5.9	11.9	7.2	8.9
Marital Status										
Married	70.9	23.8	45.5	52.5	59.0	83.7	32.2	66.3	69.6	73.4
Behavioral and health factors										
Weight Gain										
Under 25	27.0	35.6	32.1	39.8	30.5	21.7	28.4	15.9	9.7	21.9
25-35	34.4	28.4	30.8	31.8	32.8	35.1	25.9	17.4	9.3	31.3
35+	34.0	28.3	30.1	19.0	30.8	21.9	17.2	11.4	4.8	19.7
Missing	4.6	7.6	7.0	9.4	5.9	21.3	28.6	55.4	76.3	27.2
Tobacco Use										
Yes	14.4	8.5	3.4	0.4	10.7	16.7	13.8	4.8	1.0	14.8
No	79.9	83.1	93.8	95.4	83.6	59.1	63.7	47.2	30.0	57.7
Missing	5.7	8.3	2.7	4.2	5.7	24.2	22.5	48.1	69.0	27.5
Diabetes and Hypertension										
Both	0.6	0.8	0.5	0.4	0.6	0.2	0.2	0.2	0.1	0.2
Diabetes Only	3.5	2.8	3.4	4.6	3.5	1.8	1.4	1.8	1.5	1.7
Hypertension Only	4.8	5.9	3.2	2.2	4.5	3.2	3.5	2.5	1.6	3.2
Neither	90.7	89.7	92.7	92.5	90.9	89.2	88.3	80.9	90.0	88.8
Missing	0.4	0.9	0.3	0.3	0.5	5.6	6.6	14.8	6.8	6.2

Table 5.1, cont.

Health care and medical factors										
Prenatal Care										
Inadequate	10.7	20.9	19.6	23.2	14.7	11.2	29.9	28.6	39.9	16.8
Intermediate	11.4	11.4	11.1	12.8	11.6	15.1	14.0	16.1	19.8	15.3
Adequate	41.7	30.1	33.7	33.0	38.1	47.2	27.8	31.4	23.8	41.9
Adequate plus	32.3	30.3	29.4	25.0	30.8	24.0	23.4	20.3	13.2	23.1
Missing	3.9	7.3	6.3	6.0	4.9	2.5	4.9	3.6	3.4	3.0
Induction										
Yes	28.1	20.5	19.5	13.7	4.0	10.2	6.3	6.0	3.3	9.0
No	71.5	78.7	80.0	85.9	95.6	85.0	87.7	80.3	90.5	85.6
Missing	0.4	0.8	0.5	0.5	0.5	4.8	6.0	13.8	6.1	5.4
Cesarean										
Yes	28.1	20.5	19.5	13.7	24.3	21.4	19.7	19.7	16.5	21.4
No	71.5	78.7	80.0	85.9	75.3	72.2	72.3	66.1	76.6	71.6
Missing	0.4	0.8	0.5	0.5	0.4	6.4	7.6	14.2	6.7	7.0

Table 5.2 Mothers' characteristics by nativity/race/ethnicity, 1989 and 2007 – data with missing values excluded

	2007					1989				
	US NH white	**US NH black**	**US Mex**	**F Mex**	**All**	**NH white**	**NH black**	**US Mex**	**F Mex**	**All**
N	1,797,653	416,472	223,481	372,512	2,810,118	1,504,504	327,247	49,878	37,948	1,919,127
Infants's sex										
Male	51.2	50.8	51.0	51.0	51.1	51.4	50.8	51.4	51.3	51.3
Socio-economic and demographic factors										
Age										
17 & Under	2.1	6.9	9.4	3.6	3.6	3.3	11.6	10.0	4.4	4.9
18-20	5.9	12.5	13.0	7.1	7.6	7.0	14.1	13.3	8.4	8.4
20-24	23.7	34.2	32.5	27.6	26.5	25.4	33.2	32.5	33.4	27.1
25-34	53.6	38.2	38.8	49.4	49.6	56.1	36.3	38.7	46.4	52.0
35 and older	14.8	8.2	63.4	12.3	33.4	8.3	4.9	5.5	7.3	7.6
Birth Order										
First	35.3	32.9	36.7	27.1	34.0	34.4	31.3	32.6	31.1	33.8
Second	29.6	25.2	26.6	27.9	28.5	31.4	27.6	28.0	26.6	30.6
Third+	35.1	41.9	36.7	45.0	37.6	34.1	41.1	39.4	42.3	35.6
Parity										
Low Parity	81.0	75.4	78.6	83.3	80.3	82.9	74.4	77.7	81.2	81.3
High Parity	10.7	21.8	18.3	13.4	13.3	11.4	23.7	20.4	16.6	13.9
First Birth and 35+	8.3	2.8	3.1	3.4	6.4	5.7	1.9	2.0	2.1	4.9
Education										
0-12th grade	11.0	23.2	30.0	61.8	21.1	15.5	30.5	42.1	70.3	19.8
Hi school grad or GED	26.5	37.3	36.0	25.6	28.7	40.8	44.0	39.3	19.1	40.9

Table 5.2, Cont.

Some college	23.4	25.8	21.3	7.1	21.4	22.5	18.9	13.6	7.2	21.3
Associate D or higher	39.1	13.8	12.7	5.5	28.8	21.3	6.6	5.1	3.5	18.0
Marital Status										
Married	71.6	24.4	46.2	53.2	60.2	84.7	33.3	71.3	79.0	73.4
Behavioral and health factors										
Weight Gain										
Under 25	28.4	38.6	34.5	43.7	32.4	27.8	39.9	35.7	40.4	30.3
25-35	36.3	31.1	33.2	35.4	35.1	44.6	36.3	39.0	39.4	43.0
35+	35.4	30.3	32.2	20.9	32.5	27.6	23.8	25.3	20.2	26.8
Tobacco Use										
Yes	15.2	9.2	3.6	0.4	11.4	22.2	17.6	9.2	3.1	20.7
Diabetes and Hypertension										
Both	0.6	0.8	0.5	0.4	0.6	0.2	0.3	0.3	0.2	0.2
Diabetes Only	3.5	2.7	3.4	4.7	3.5	2.0	1.6	2.4	2.3	1.9
Hypertension Only	4.8	5.9	3.3	2.3	4.5	3.6	3.8	3.4	2.4	3.6
Neither	91.1	90.6	92.8	92.6	91.4	94.2	94.4	93.9	95.2	94.2
Health care and medical factors										
Prenatal Care										
Inadequate	10.6	21.5	20.6	24.2	14.8	10.8	29.3	28.4	40.2	15.0
Intermediate	12.0	12.5	11.8	13.8	12.3	15.3	14.6	17.0	18.6	15.2
Adequate	43.8	32.8	36.1	35.3	40.4	49.5	30.9	34.2	27.4	45.5
Adequate plus	33.7	33.1	31.5	26.7	32.5	24.4	25.2	20.4	13.8	24.2

Table 5.2, Cont.

Induction										
Yes	28.7	21.2	20.7	14.4	25.1	11.6	7.3	8.9	5.6	10.7
Cesarean										
Yes	30.1	31.8	28.8	27.7	30.0	22.7	21.6	23.0	19.0	22.5

Table 5.3 Mean birthweight of singleton births by mothers characteristics, 1989 and 2007

	2,007 **US NH white**	**US NH black**	**US Mex**	**F Mex**	**All**	**1,989** **NH white**	**NH black**	**US Mex**	**F Mex**	**All**
Infants's sex										
Female	3,294	3,026	3,236	3,290	3,246	3,367	3,057	3,288	3,339	3,309
Male	3,412	3,136	3,324	3,383	3,358	3,495	3,169	3,392	3,448	3,434
Socio-economic and demographic factors										
Mother's Age										
Under 18	3,212	3,016	3,179	3,212	3,147	3,282	3,055	3,231	3,242	3,187
18-20	3,235	3,034	3,222	3,251	3,184	3,330	3,089	3,267	3,280	3,256
20-24	3,298	3,075	3,272	3,308	3,251	3,399	3,117	3,336	3,360	3,335
25-34	3,387	3,117	3,329	3,370	3,348	3,464	3,132	3,392	3,444	3,420
35 and older	3,397	3,075	3,306	3,361	3,356	3,469	3,147	3,396	3,476	3,432
Birth Order										
First	3,312	3,051	3,237	3,258	3,260	3,383	3,104	3,285	3,291	3,330
Second	3,382	3,103	3,305	3,343	3,332	3,456	3,144	3,362	3,401	3,402
Third+	3,384	3,111	3,315	3,376	3,336	3,470	3,134	3,375	3,451	3,407
Fourth and higher	3,366	3,082	3,299	3,387	3,308	3,459	3,076	3,375	3,488	3,372
Missing	3,314	3,040	3,216	3,341	3,247	3,408	3,030	3,311	3,352	3,328
Parity										
Low Parity	3,365	3,085	3,283	3,336	3,315	3,441	3,127	3,342	3,387	3,387
High Parity	3,287	3,074	3,274	3,353	3,240	3,390	3,073	3,338	3,440	3,290
First Birth and 35+	3,303	2,997	3,214	3,233	3,271	3,339	3,068	3,260	3,251	3,317
Education										
0-12th grade	3,212	3,015	3,229	3,338	3,229	3,290	3,039	3,295	3,398	3,252
Hi school grad or GED	3,305	3,069	3,284	3,336	3,259	3,421	3,120	3,367	3,394	3,360
Some college	3,366	3,117	3,311	3,336	3,314	3,475	3,177	3,402	3,392	3,423
Associate D or higher	3,424	3,173	3,347	3,339	3,400	3,506	3,246	3,409	3,387	3,487
Unknown	3,280	2,992	3,259	3,323	3,246	3,450	3,101	3,320	3,372	3,402

Table 5.3, Cont.

Married										
Yes	3,394	3,153	3,322	3,356	3,370	3,460	3,211	3,371	3,417	3,436
No	3,258	3,060	3,246	3,317	3,208	3,297	3,067	3,280	3,343	3,200
Behavioral and health factors										
Weight Gain										
Under 25	3,220	2,946	3,165	3,257	3,172	3,270	2,955	3,197	3,284	3,199
25-35	3,346	3,104	3,281	3,367	3,311	3,442	3,183	3,356	3,413	3,403
35+	3,475	3,246	3,406	3,472	3,436	3,594	3,353	3,487	3,537	3,555
Missing	3,314	3,019	3,274	3,303	3,248	3,420	3,062	3,348	3,398	3,347
Tobacco Use										
Yes	3,149	2,930	3,165	3,240	3,122	3,218	2,915	3,163	3,272	3,170
No	3,393	3,099	3,285	3,338	3,329	3,490	3,158	3,337	3,376	3,419
Unknown	3,334	3,065	3,287	3,325	3,269	3,445	3,107	3,363	3,405	3,387
Diabetes and Hypertension										
Both	3,256	2,988	3,183	3,182	3,187	3,357	3,180	3,416	3,416	3,327
Diabetes Only	3,416	3,264	3,418	3,412	3,397	3,516	3,360	3,509	3,571	3,497
Hypertension Only	3,135	2,819	2,986	3,015	3,053	3,281	2,972	3,143	3,123	3,214
Neither	3,365	3,095	3,286	3,342	3,313	3,438	3,117	3,348	3,398	3,378
Missing	3,296	3,007	3,308	3,296	3,211	3,422	3,093	3,313	3,365	3,349
Health care and medical factors										
Prenatal Care										
Inadequate	3,279	3,019	3,268	3,312	3,222	3,308	3,001	3,273	3,346	3,222
Intermediate	3,289	3,056	3,234	3,316	3,237	3,338	3,045	3,298	3,376	3,252
Adequate	3,431	3,187	3,351	3,400	3,382	3,499	3,213	3,402	3,444	3,446
Adequate plus	3,435	3,199	3,361	3,397	3,396	3,505	3,242	3,414	3,441	3,470
Missing	3,254	2,959	3,196	3,251	3,204	3,305	3,008	3,245	3,292	3,251

Table 5.3, Cont.

Induction										
Yes	3,410	3,170	3,340	3,386	3,372	3,513	3,183	3,412	3,435	3,469
No	3,333	3,060	3,266	3,330	3,282	3,424	3,110	3,340	3,395	3,364
Unknown	3,301	3,012	3,280	3,312	3,220	3,427	3,093	3,317	3,369	3,350
Cesarean										
Yes	3,344	3,064	3,282	3,339	3,292	3,438	3,145	3,372	3,443	3,388
No	3,359	3,089	3,280	3,336	3,308	3,432	3,105	3,336	3,387	3,370
Unknown	3,466	3,225	3,407	3,461	3,421	3,435	3,119	3,319	3,364	3,364

Table 5.4.1 OLS regression models on mean birthweight for all, from 1989 to 2007

	Model1	Model2	Model3	Model4	Model5	Model6
Year	-3.7	-3.8	-4.2	-4.7	-4.5	-1.6
Infant' Sex						
Female	REF	REF	REF	REF	REF	REF
Male	116.4	115.6	115.7	111.1	112.9	125.1
Socio-economic and demographic factors						
Race						
US NH white		REF	REF	REF	REF	REF
US NH black		-290.8	-226.7	-234.9	-219.9	-161.9
US Mexican		-84.6	-29.3	-56.0	-48.9	-35.9
FB Mexican		-32.3	35.8	0.8	4.8	8.1
Mother's Age						
Under 18			-9.7	-41.8	-37.2	-12.4
18-20			-18.1	-33.2	-31.6	-29.2
20-24			-5.7	-9.5	-9.5	-16.9
25-34			REF	REF	REF	REF
35 and older			-21.7	-16.8	-11.4	2.3
Birth Order						
First			REF	REF	REF	REF
Second			62.9	78.8	81.2	91.7
Third			88.4	108.7	110.9	126.5
Fourth and higher			86.5	113.8	117.0	143.2
Missing			28.8	43.9	66.1	81.8
Parity						
High Parity			-48.2	-41.3	-38.4	-36.1
Low Parity			REF	REF	REF	REF
1st birth and 35+			-59.6	-45.2	-41.3	-36.7
Education						
Less than High School			REF	REF	REF	REF
High School Graduate			56.0	31.0	28.9	26.0
Associate Degree			100.3	57.1	53.8	48.9
Bachelor's and higher			136.6	74.7	69.4	65.0
Missing			50.3	13.3	12.2	19.4
Married						
Yes			73.3	53.4	50.4	37.7
No			REF	REF	REF	REF
Behavioral and health factors						
Diabetes and Hypertension						
Both				-86.8	-54.7	20.8
Diabetes Only				106.7	123.0	128.5
Hypertension Only				-237.7	-231.4	-153.1

Table 5.4.1, Cont.

Neither	REF	REF		REF
Missing	-37.3	-44.4		-24.7
Weight Gain				
Under 15	-138.6	-133.8		-91.6
15-25	REF	REF		REF
25 and up	158.8	156.1		128.4
Missing	-29.5	-16.4		6.2
Smoking				
Yes	-216.7	-213.6		-202.8
No	REF	REF		REF
Missing	19.6	14.9		-6.8
Health care and medical factors				
Prenatal Care				
Inadequate		-79.9		-54.3
Intermediate		11.4		-87.0
Adequate		REF		REF
Adequate Plus		-186.8		-0.158
Missing		-139.7		-59.4
Induction				
Yes		86.4		34.4
No		REF		REF
Missing		-0.404	†	-12.1
Cesarean section				
Yes		5.0		26.5
No		REF		REF
Missing		49.9		46.0
Gestation (wk)				110.6

Table 5.4.2 OLS Regression Models on Mean Birthweight for NH whites, from 1989 to 2007

	Model1	Model2	Model3	Model4	Model5
Year	-4.4	-4.8	-5.5	-5.3	-1.6
Infant' Sex					
Female	REF	REF	REF	REF	REF
Male	121.1	121.1	116.0	118.0	130.8
Socio-economic and demographic factors					
Mother's Age					
Under 18		25.9	-23.5	-20.2	1.1
18-20		-2.1	-22.5	-21.6	-21.3
20-24		-0.2	-4.3	-4.5	-12.5
25-34		REF	REF	REF	REF
35 and older		-19.6	-15.7	-10.1	1.3
Birth Order					
First		REF	REF	REF	REF
Second		65.3	83.8	85.6	96.7
Third		91.1	113.8	114.9	131.5
Fourth and higher		97.2	125.4	126.9	151.1
Missing		44.9	55.8	78.3	90.6
Parity					
High Parity		-61.6	-48.8	-45.0	-42.9
Low Parity		REF	REF	REF	REF
1st birth and 35+		-58.2	-42.3	-39.0	-34.8
Education					
Less than High School		REF	REF	REF	REF
High School Graduate		91.7	52.7	49.2	46.6
Associate Degree		139.0	80.3	75.2	71.8
Bachelor's and higher		173.1	97.3	90.6	85.1
Missing		104.5	47.2	43.9	47.2
Married					
Yes		85.0	57.8	54.9	44.7
No		REF	REF	REF	REF
Behavioral and health factors					
Diabetes and Hypertension					
Both			-83.2	-47.7	26.7

Table 5.4.2, Cont.

Diabetes Only	90.4	108.4	117.3
Hypertension Only	-222.4	-214.5	-140.3
Neither	REF	REF	REF
Missing	-30.9	-37.1	-20.3
Weight Gain			
Under 15	-129.6	-124.9	-88.7
15-25	REF	REF	REF
25 and up	161.6	159.1	131.9
Missing	-6.4	7.7	19.9
Smoking			
Yes	-217.7	-214.6	-206.0
No	REF	REF	REF
Missing	-3.0	-7.3	-22.4
Health care and medical factors			
Prenatal Care			
Inadequate		-71.0	-57.2
Intermediate		14.6	-89.6
Adequate		REF	REF
Adequate Plus		-182.2	-4.7
Missing		-144.9	-62.3
Induction			
Yes		88.5	37.9
No		REF	REF
Missing		-0.9	-12.5
Cesarean section			
Yes		3.8	27.8
No		REF	REF
Missing		49.3	47.1
Gestation (wk)			112.4

Table 5.4.3 OLS regression models on mean birthweight for non-Hispanic blacks, from 1989 to 2007

	Model1	Model2	Model3	Model4	Model5
Year	-1.8	-2.1	-3.3	-3.3	-1.6
Infant' Sex					
Female	REF	REF	REF	REF	REF
Male	110.6	110.7	105.8	107.2	115.5
Socio-economic and demographic factors					
Mother's Age					
Under 18		40.0	53.1	57.1	67.2
18-20		44.1	64.4	69.6	88.4
20-24		9.4	40.6	47.5	87.8
25-34		REF	REF	REF	REF
35 and older		-32.8	-0.5	27.5	54.5
Birth Order					
First		REF	REF	REF	REF
Second		40.0	53.1	57.1	67.2
Third		44.1	64.4	69.6	88.4
Fourth and higher		9.4	40.6	47.5	87.8
Missing		-32.8	-0.5	27.5	54.5
Parity					
High Parity		-3.9	-7.2	-6.7	-7.9
Low Parity		REF	REF	REF	REF
1st birth and 35+		-79.4	-62.4	-54.5	-32.5
Education					
Less than High School		REF	REF	REF	REF
High School Graduate		53.5	26.3	25.7	22.0
Associate Degree		95.9	51.5	51.1	40.2
Bachelor's and higher		135.3	77.2	75.3	64.7
Missing		-3.6	-20.4	-19.1	7.7
Married					
Yes		81.5	64.4	62.4	36.8
No		REF	REF	REF	REF
Behavioral and health factors					
Diabetes and Hypertension					
Both			-71.9	-38.2	43.4

Table 5.4.3, Cont.

Diabetes Only	185.4	202.3	200.8
Hypertension Only	-261.4	-254.1	-161.5
Neither	REF	REF	REF
Missing	-37.2	-51.2	-22.1
Weight Gain			
Under 15	-180.6	-174.8	-101.2
15-25	REF	REF	REF
25 and up	159.9	155.7	119.9
Missing	-101.0	-87.1	-32.8
Smoking			
Yes	-186.9	-186.9	-157.4
No	REF	REF	REF
Missing	34.6	29.2	-0.6
Health care and medical factors			
Prenatal Care			
Inadequate		-106.3	-38.0
Intermediate		1.7	-88.1
Adequate		REF	REF
Adequate Plus		-232.8	19.6
Missing		-164.0	-50.4
Induction			
Yes		88.1	19.6
No		REF	REF
Missing		-0.3	-10.3
Cesarean section			
Yes		-5.8	11.5
No		REF	REF
Missing		67.5	48.7
Gestation (wk)			114.8

Table 5.4.4 OLS regression models on mean birthweight for US-born Mexicans, from 1989 to 2007

	Model1	Model2	Model3	Model4	Model5
Year	-3.5	-3.8	-3.6	-3.6	-1.3
Infant' Sex					
Female	REF	REF	REF	REF	REF
Male	95.5	95.8	93.0	94.9	108.9
Socio-economic and demographic factors					
Mother's Age					
Under 18		-69.4	-74.4	-67.6	-42.9
18-20		-53.0	-55.4	-51.6	-43.6
20-24		-20.5	-21.0	-20.0	-22.3
25-34		REF	REF	REF	REF
35 and older		-29.0	-26.8	-21.7	-2.4
Birth Order					
First		REF	REF	REF	REF
Second		54.5	65.0	69.1	80.3
Third		74.0	87.7	93.4	110.2
Fourth and higher		65.3	82.2	90.4	118.3
Missing		-24.7	-3.7	5.5	32.0
Parity					
High Parity		-29.8	-25.6	-24.8	-24.1
Low Parity		REF	REF	REF	REF
1st birth and 35+		-64.6	-54.2	-50.9	-43.5
Education					
Less than High School		REF	REF	REF	REF
High School Graduate		33.7	25.1	22.8	19.0
Associate Degree		56.7	42.8	39.4	33.4
Bachelor's and higher		71.8	55.4	51.2	43.9
Missing		-3.1	3.3	0.4	4.3
Married					
Yes		37.7	41.8	39.2	27.1
No		REF	REF	REF	REF
Behavioral and health factors					
Diabetes and Hypertension					
Both			-85.4	-63.8	12.7

Table 5.4.4, Cont.

Diabetes Only	132.6	142.1	148.1
Hypertension Only	-285.3	-288.3	-203.9
Neither	REF	REF	REF
Missing	-60.3	-58.8	-37.1
Weight Gain			
Under 15	-131.9	-128.8	-93.9
15-25	REF	REF	REF
25 and up	144.8	140.7	118.7
Missing	-44.7	-37.0	-10.7
Smoking			
Yes	-148.2	-150.0	-142.6
No	REF	REF	REF
Missing	95.9	91.9	51.8
Health care and medical factors			
Prenatal Care			
Inadequate		-82.8	-49.4
Intermediate		5.1	-82.3
Adequate		REF	REF
Adequate Plus		-169.4	4.9
Missing		-103.6	-40.8
Induction			
Yes		82.1	35.9
No		REF	REF
Missing		-9.5	-18.2
Cesarean section			
Yes		13.7	33.9
No		REF	REF
Missing		30.9	39.0
Gestation (wk)			100.2

Table 5.4.5 OLS regression models on mean birthweight for foreign-born Mexicans, from 1989 to 2007

	Model1	Model2	Model3	Model4	Model5
Year	-3.3	-3.7	-3.0	-2.7	-1.7
Infant' Sex					
Female	REF	REF	REF	REF	REF
Male	98.1	98.5	96.9	98.1	110.5
Socio-economic and demographic factors					
Mother's Age					
Under 18		-98.8	-97.0	-87.9	-60.1
18-20		-76.2	-74.0	-68.0	-53.7
20-24		-33.4	-32.4	-30.1	-28.9
25-34		REF	REF	REF	REF
35 and older		-22.7	-21.3	-17.7	4.3
Birth Order					
First		REF	REF	REF	REF
Second		84.0	87.8	90.4	97.6
Third		120.8	126.2	130.3	141.6
Fourth and higher		145.3	153.3	159.5	177.3
Missing		52.0	64.6	77.1	91.3
Parity					
High Parity		-33.4	-31.6	-31.5	-33.2
Low Parity		REF	REF	REF	REF
1st birth and 35+		-23.7	-17.6	-18.2	-16.7
Education					
Less than High School		REF	REF	REF	REF
High School Graduate		3.7	-3.1	-3.2	-2.7
Associate Degree		5.8	-4.7	-3.6	-4.4
Bachelor's and higher		1.0	-9.9	-9.1	-8.6
Missing		-18.9	-9.6	-9.4	-3.2
Married					
Yes		27.3	26.6	25.0	15.7
No		REF	REF	REF	REF
Behavioral and health factors					
Diabetes and Hypertension					
Both			-149.5	-137.1	-58.6

Table 5.4.5, Cont.

Diabetes Only	91.4	99.3	103.8
Hypertension Only	-309.1	-314.4	-228.7
Neither	REF	REF	REF
Missing	-32.7	-41.1	-29.6
Weight Gain			
Under 15	-126.6	-124.1	-95.0
15-25	REF	REF	REF
25 and up	128.2	126.1	110.6
Missing	-60.6	-53.9	-32.1
Smoking			
Yes	-118.8	-118.2	-113.1
No	REF	REF	REF
Missing	57.9	57.6	33.1
Health care and medical factors			
Prenatal Care			
Inadequate		-55.7	-47.5
Intermediate		13.3	-58.7
Adequate		REF	REF
Adequate Plus		-154.9	6.5
Missing		-73.1	-33.0
Induction			
Yes		63.4	17.8
No		REF	REF
Missing		6.0	0.0
Cesarean section			
Yes		24.8	43.3
No		REF	REF
Missing		38.5	43.9
Gestation (wk)			94.9

Table 6.1 Regression decomposition for singleton birthweight difference in the US, 1989 and 2007

	1989	2007		Difference
Birthweight	3,373	3,303		70
Decomposition				
Col 1	Col 2	Col 3	Col 4	Col 5
	E (grams)	E (%)	C (Grams)	E (%)
Total	28	40.4	42	59.6
Intercept			489	1174.7
Infant' Sex	0	0.3	6	13.8
Race	-3	-11.0	2	4.3
Mother's Age	0	-0.9	7	17.5
Birth Order	-1	-3.9	2	4.0
Parity	0	0.8	-2	-4.0
Education	-5	-17.1	15	36.6
Married	7	23.4	9	20.5
Diabetes and Hypertension	-2	-5.5	2	5.1
Weight Gain	-9	-30.6	-6	-14.4
Smoking	-12	-44.3	-3	-7.0
Prenatal Care	-3	-9.5	-12	-29.7
Induction	-3	-12.4	-2	-3.8
Cesarean section	-1	-5.0	-1	-3.1
Gestation (wk)	61	215.8	-464	-1114.6

Table 6.2.1 Regression decomposition for US-Born white birthweight difference in the US, 1989 and 2007

	1989	2007		Difference
Birthweight	3,439	3,360		79
Decomposition				
Col 1	Col 2	Col 3	Col 4	Col 5
	E (grams)	E(%)	C(Grams)	E (%)
Total	38	48.6	41	51.4
Intercept			408	1005.7
Infant' Sex	0	0.3	5	13.4
Mother's Age	0	-0.1	3	8.5
Birth Order	0	-1.1	4	9.0
Parity	0	0.8	-1	-2.4
Education	-9	-22.8	13	31.0
Married	6	16.9	8	19.9
Diabetes and Hypertension	-1	-2.1	1	3.6
Weight Gain	-12	-30.4	-5	-13.4
Smoking	-10	-26.5	-5	-11.1
Prenatal Care	-2	-4.7	-10	-25.8
Induction	-5	-11.9	-1	-3.4
Cesarean section	-2	-4.4	-2	-5.3
Gestation (wk)	71	186.0	-377	-929.6

Table 6.2.2 Regression decomposition for US-Born black birthweight difference in the US, 1989 and 2007

	1989	2007		Difference
Birthweight	3,124	3,092		32
Decomposition				
Col 1	Col 2	Col 3	Col 4	Col 5
	E (grams)	E(%)	C(Grams)	E (%)
Total	-5	-16.7	37	116.7
Intercept			856	2305.4
Infant' Sex	0	1.3	1	1.7
Mother's Age	1	-13.7	18	48.9
Birth Order	1	-18.2	-14	-36.8
Parity	0	1.6	-2	-5.2
Education	-5	102.4	-1	-3.3
Married	4	-75.2	3	9.1
Diabetes and Hypertension	-1	16.4	3	8.9
Weight Gain	-18	329.2	-16	-41.8
Smoking	-12	216.1	-4	-9.6
Prenatal Care	-8	141.4	-7	-20.2
Induction	1	-14.0	-6	-16.6
Cesarean section	1	-12.7	1	3.0
Gestation (wk)	31	-574.7	-796	-2143.4

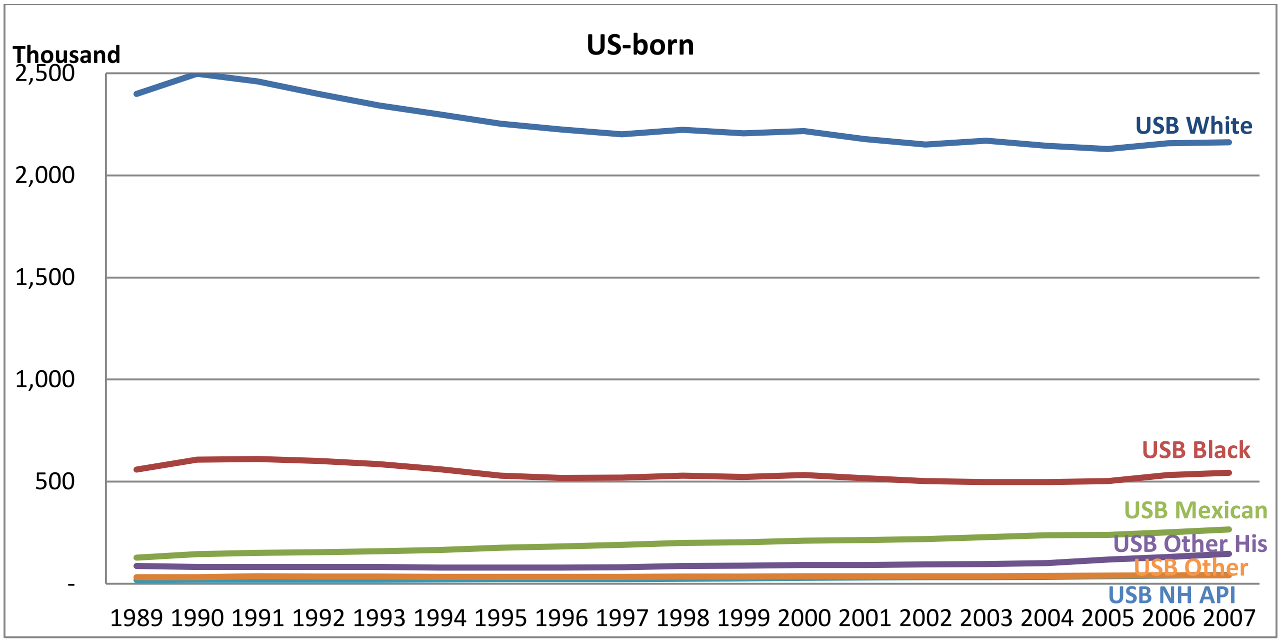
Table 6.2.3 Regression decomposition for US-Born Mexican birthweight difference in the US, 1989 and 2007

	1989	2007		Difference
Birthweight	3,345	3,284		61
Decomposition				
Col 1	Col 2	Col 3	Col 4	Col 5
	E (grams)	E(%)	C(Grams)	E (%)
Total	36	59.2	25	40.8
Intercept			802	3255.4
Infant' Sex	0	0.0	6	24.5
Mother's Age	0	-1.3	4	16.8
Birth Order	3	7.2	-6	-24.4
Parity	0	-0.1	-1	-4.0
Education	-4	-12.5	4	16.4
Married	7	21.0	6	26.3
Diabetes and Hypertension	-5	-14.8	2	7.8
Weight Gain	-17	-47.3	-11	-43.8
Smoking	20	56.1	0	-1.8
Prenatal Care	-8	-21.1	-7	-29.2
Induction	-4	-10.9	-2	-9.4
Cesarean section	-3	-7.5	0	1.9
Gestation (wk)	47	131.2	-773	-3136.6

Table 6.2.4 Regression decomposition for foreign-born Mexican birthweight difference in the US, 1989 and 2007

	1989	2007		Difference
Birthweight	3,400	3,341		59
Decomposition				
Col 1	Col 2	Col 3	Col 4	Col 5
	E (grams)	E(%)	C(Grams)	E (%)
Total	32	55.2	26	44.8
Intercept			548	2130.6
Infant' Sex	0	-0.1	7	26.7
Mother's Age	-3	-10.4	1	4.4
Birth Order	-7	-20.9	12	45.3
Parity	-1	-1.7	-1	-2.3
Education	1	2.3	0	1.9
Married	6	17.5	14	55.1
Diabetes and Hypertension	-4	-11.6	4	14.4
Weight Gain	-9	-27.4	-1	-2.6
Smoking	27	86.0	2	7.2
Prenatal Care	-12	-37.6	-11	-42.0
Induction	0	-1.5	-3	-9.9
Cesarean section	-7	-21.1	7	28.0
Gestation (wk)	40	126.3	-554	-2156.6

Figure 4.1 Trends in total number of births to US-born and to foreign-born mothers by race/ethnicity, United States, 1989-2007



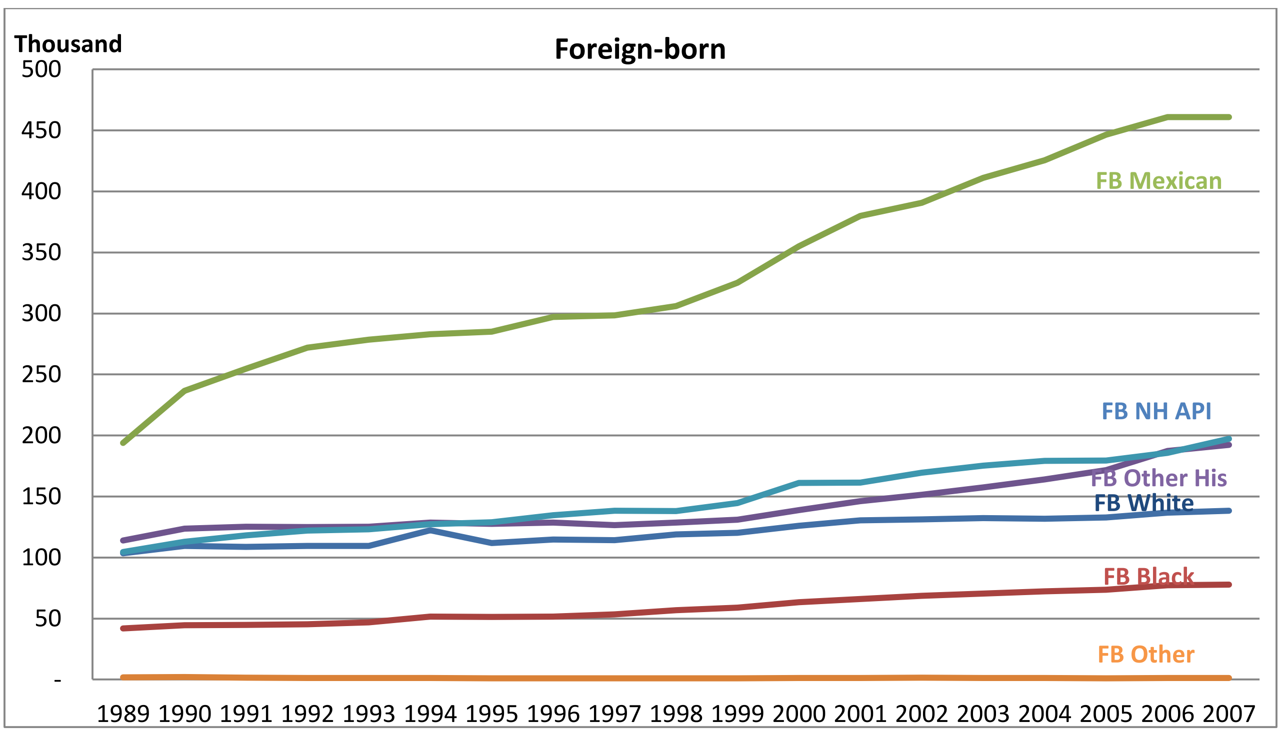
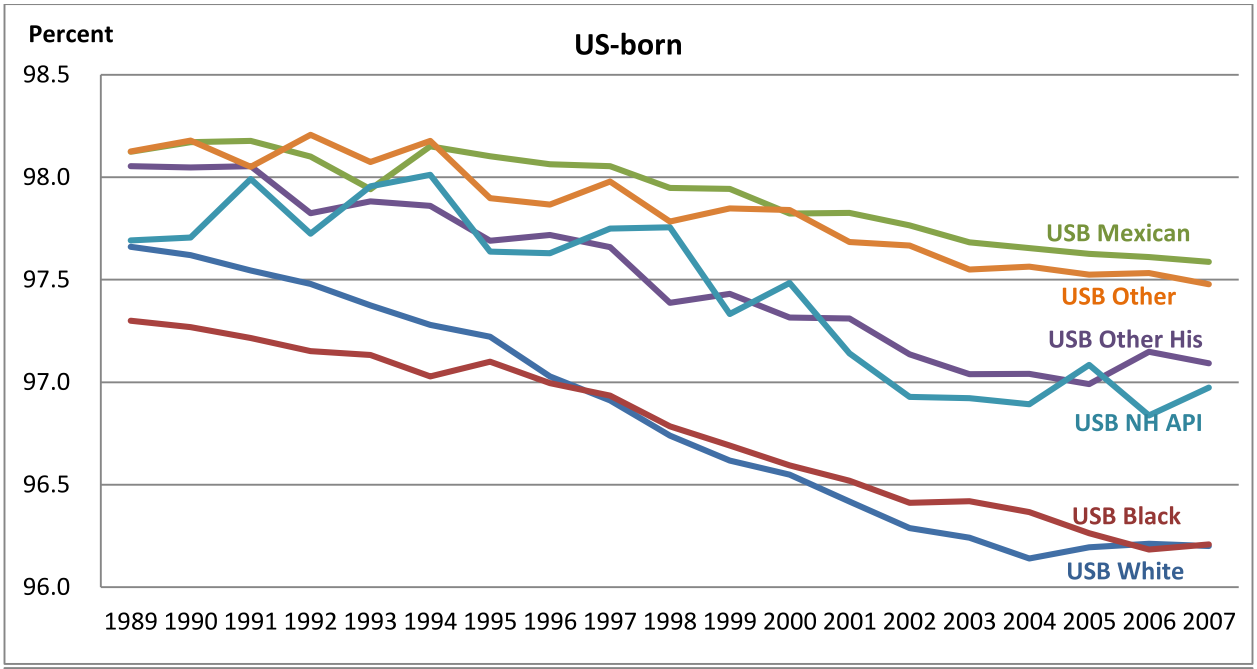


Figure 4.2 Trends in percentage of singletons born to US-born and to foreign-born mothers by race/ethnicity, United States, 1989-2007



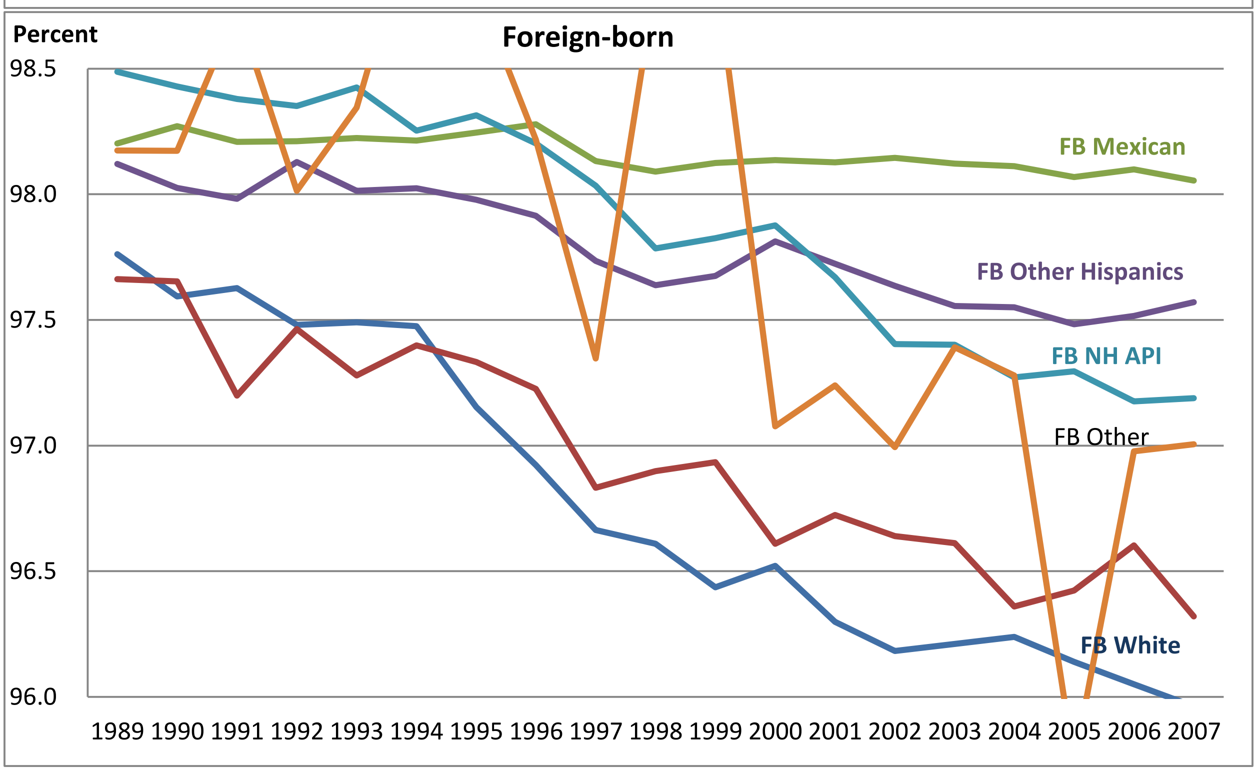


Figure 4.3 Trends in mean birthweight for singletons born to US-born and to foreign-born mothers by race/ethnicity, United States, 1989-2007

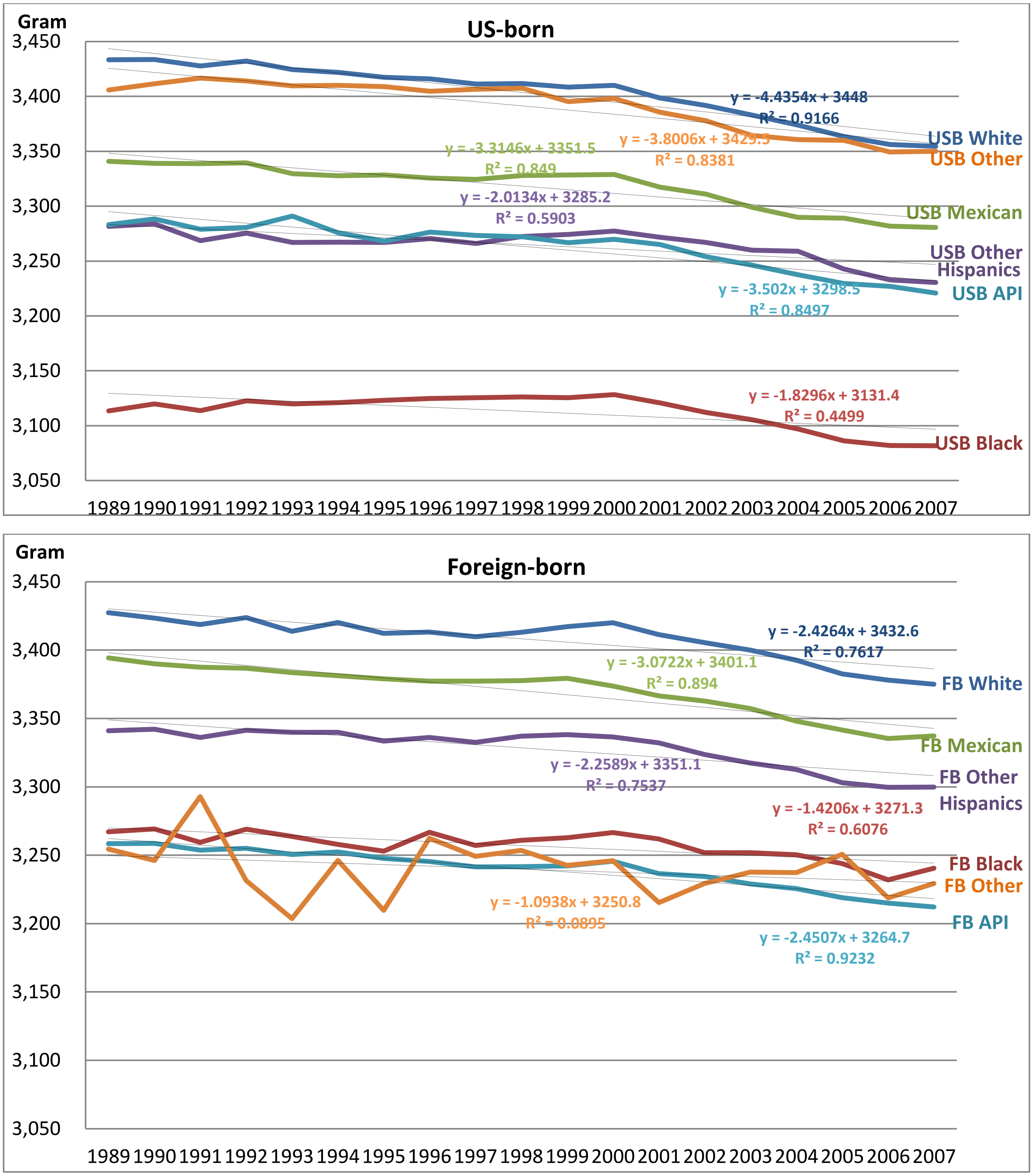
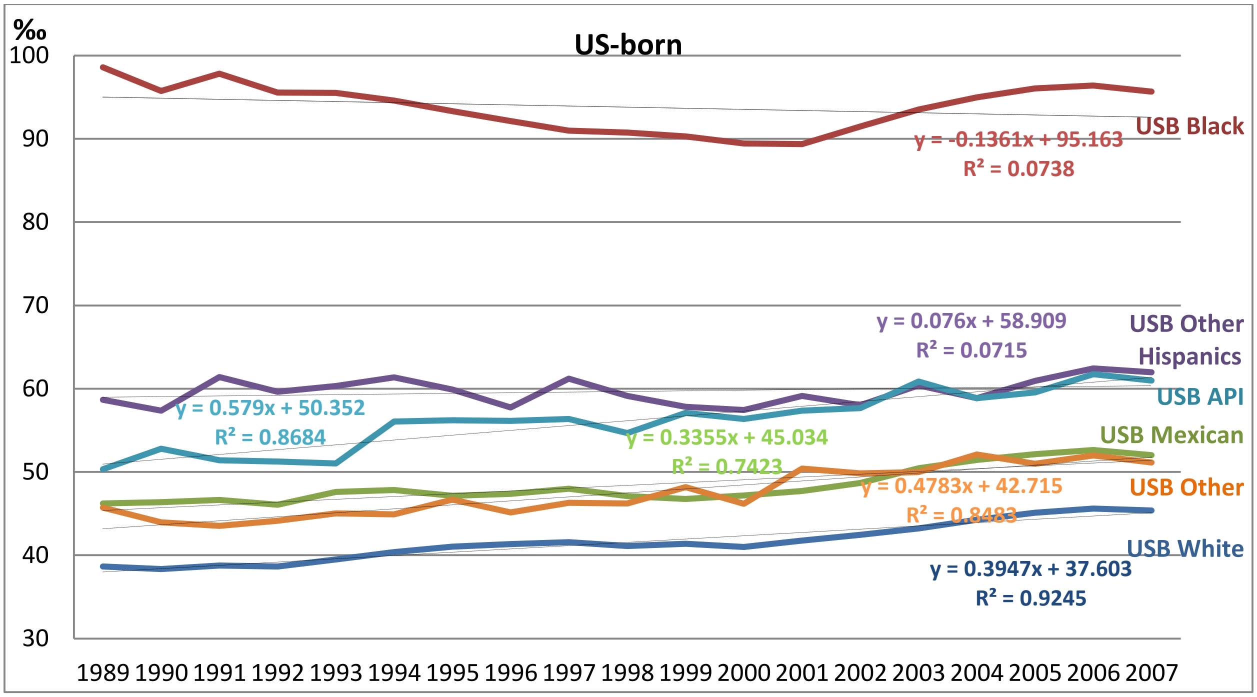


Figure 4.4 Trends in low birthweight rates (per thousand) for singletons born to US-born and to foreign-born mothers by race/ethnicity, United States, 1989-2007



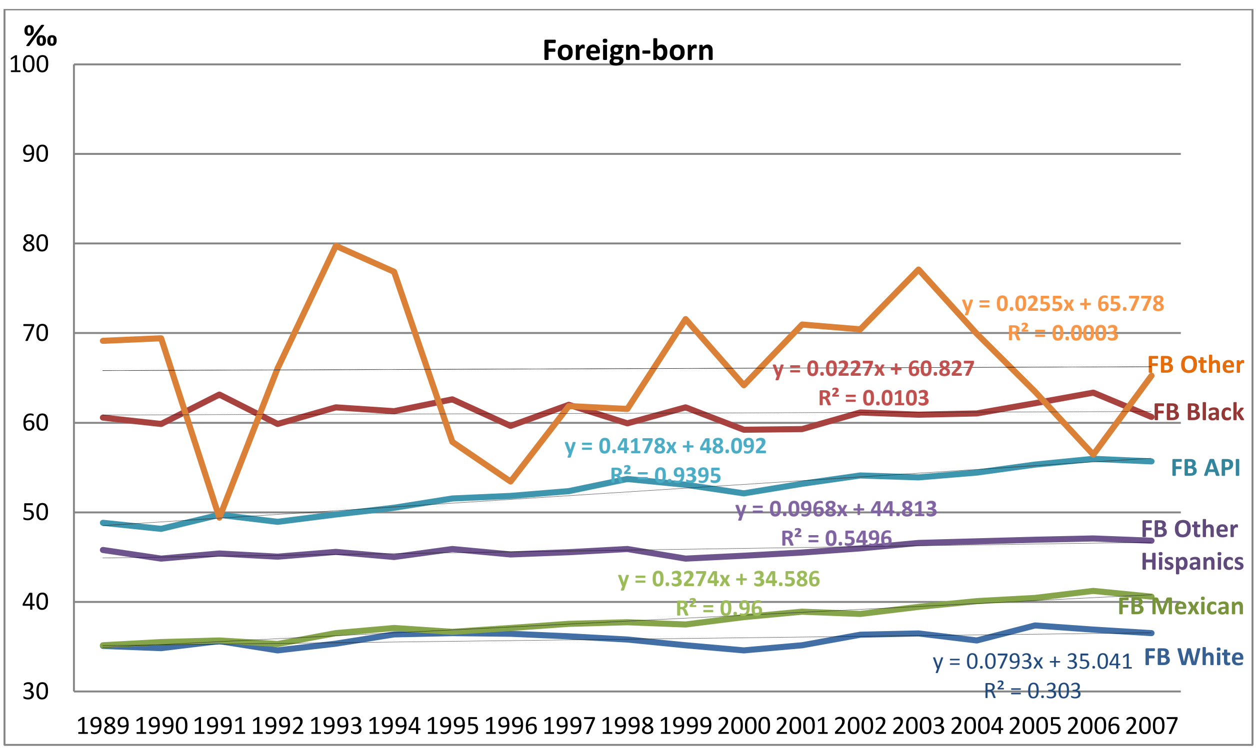


Figure 4.5 Trends in very low birthweight rates (per thousand) for singletons born to US-born and to foreign-born mothers by race/ethnicity, United States, 1989-2007

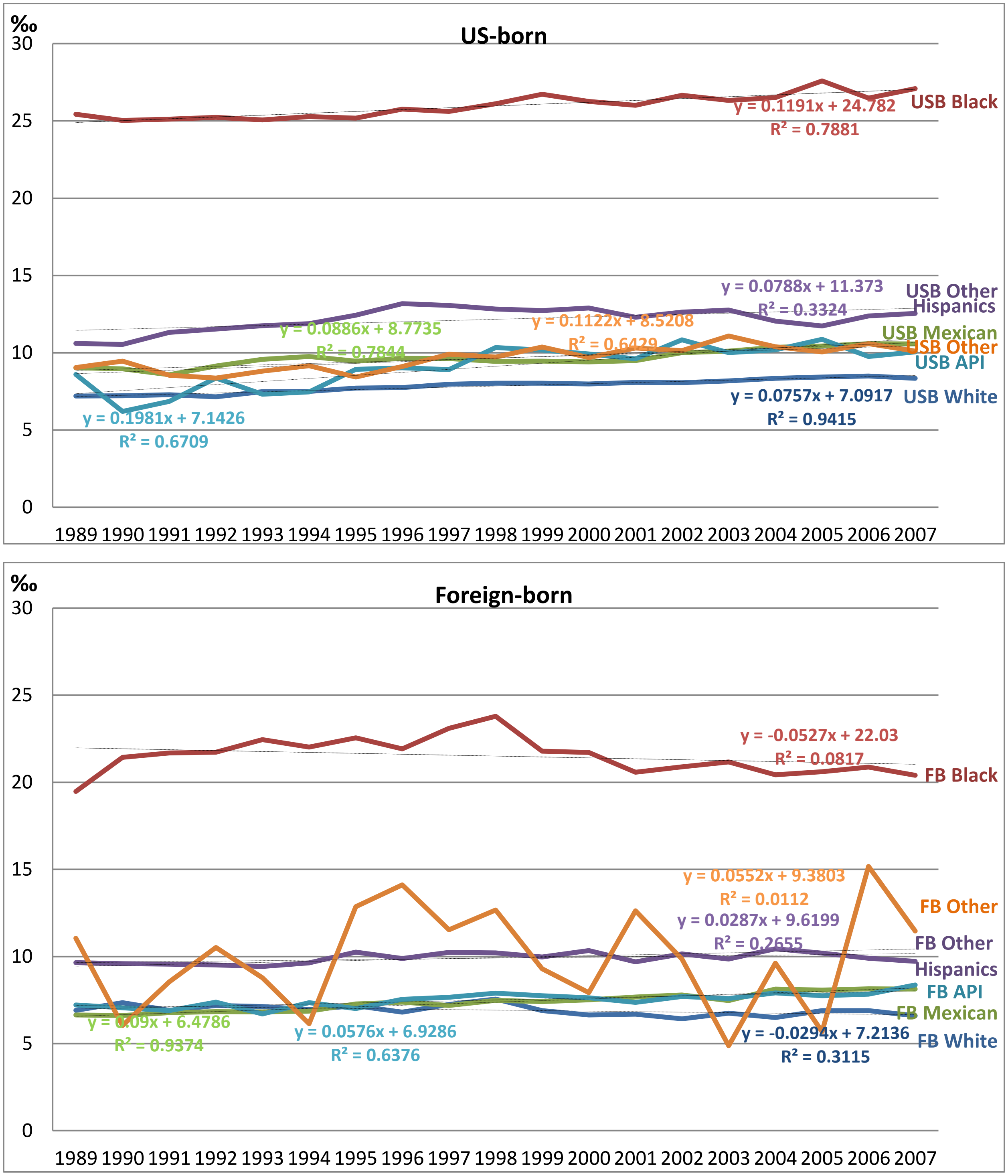
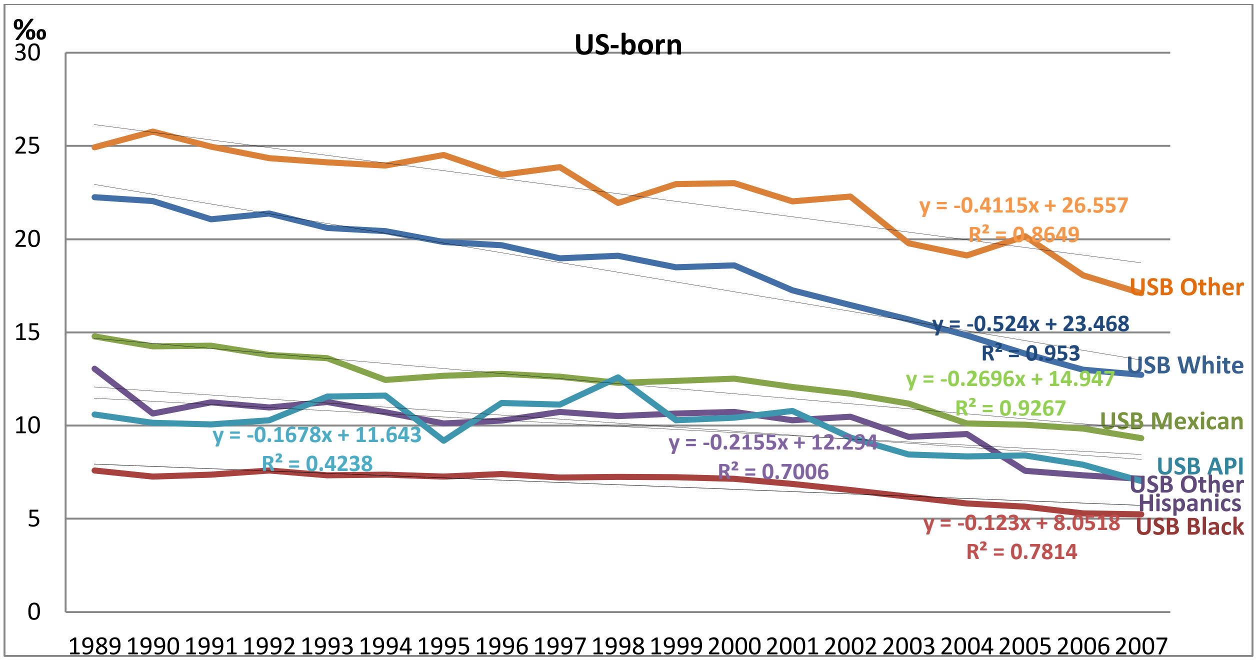


Figure 4.6 Trends in number (per thousand) singletons born at 4,500 grams or more to US-born and to foreign-born mothers by race/ethnicity, United States, 1989-2007



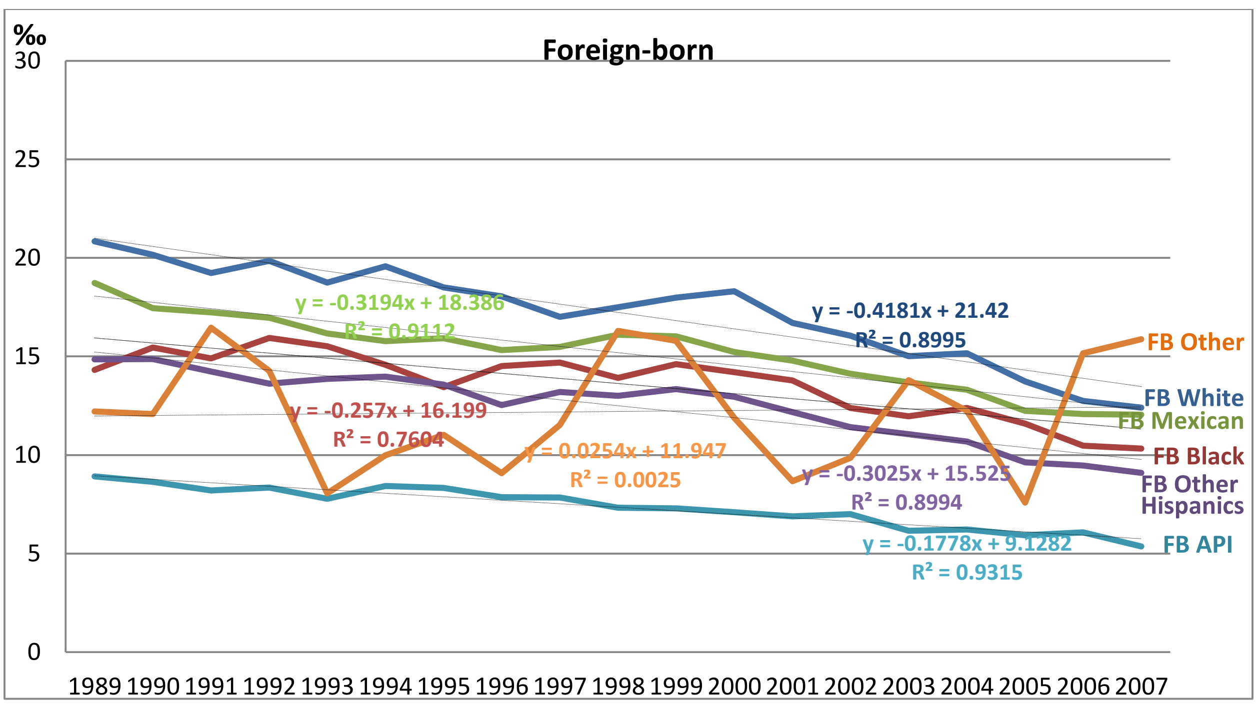


Figure 4.7 Trends in mean gestational age for singletons born to US-born mothers and to foreign-born mothers by race/ethnicity, United States, 1898-2007

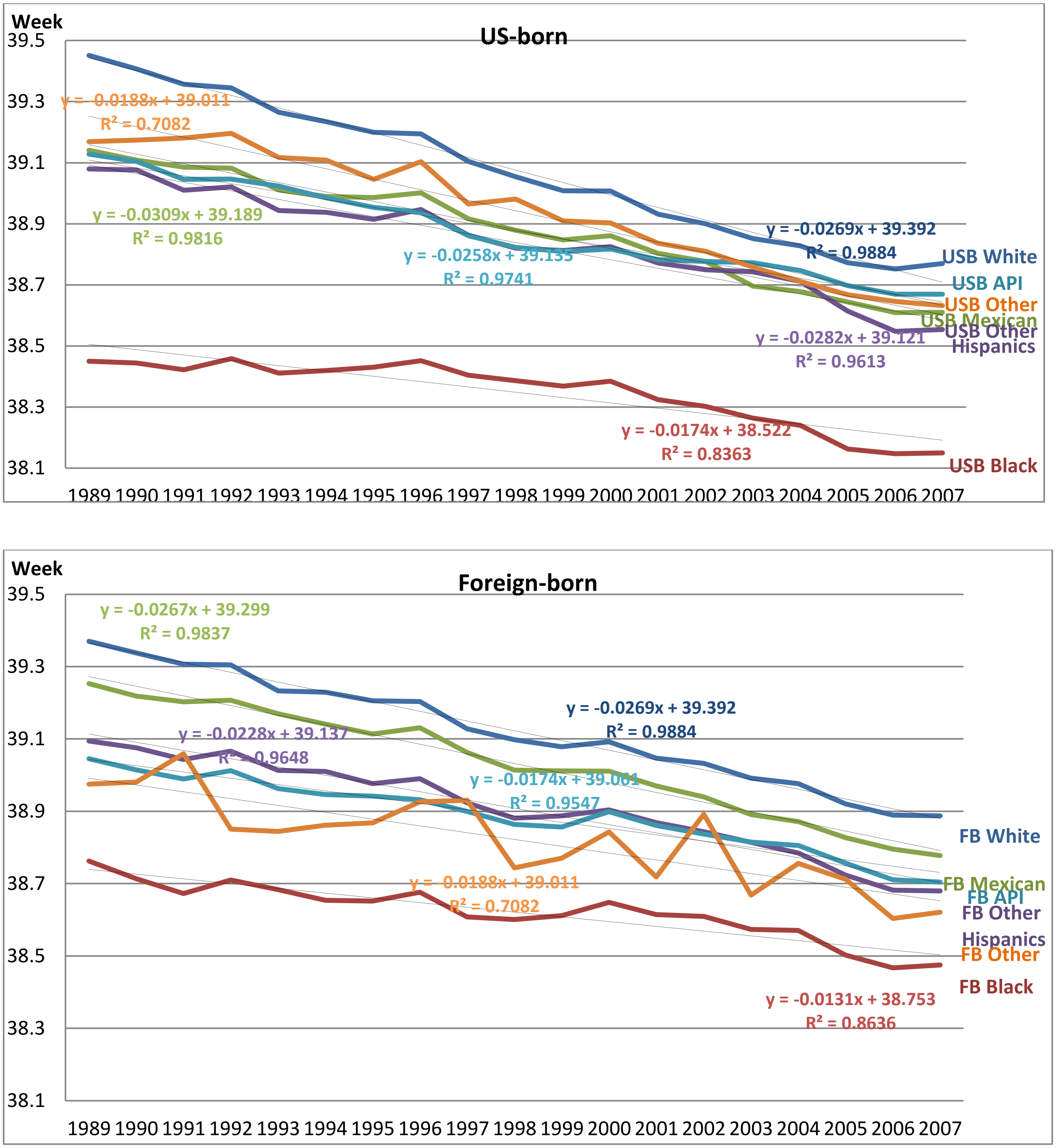
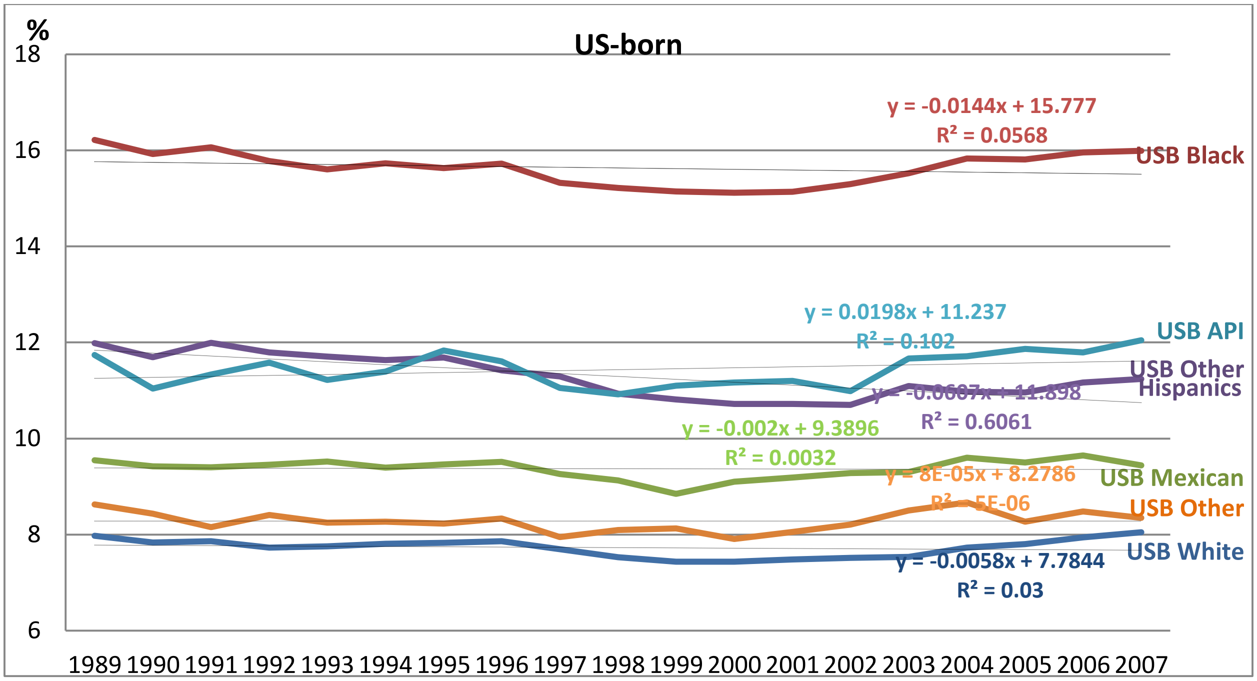


Figure 4.8 Trends in percent SGA singletons born to US-born and to foreign-born mothers by race/ethnicity, United States, 1989-2007



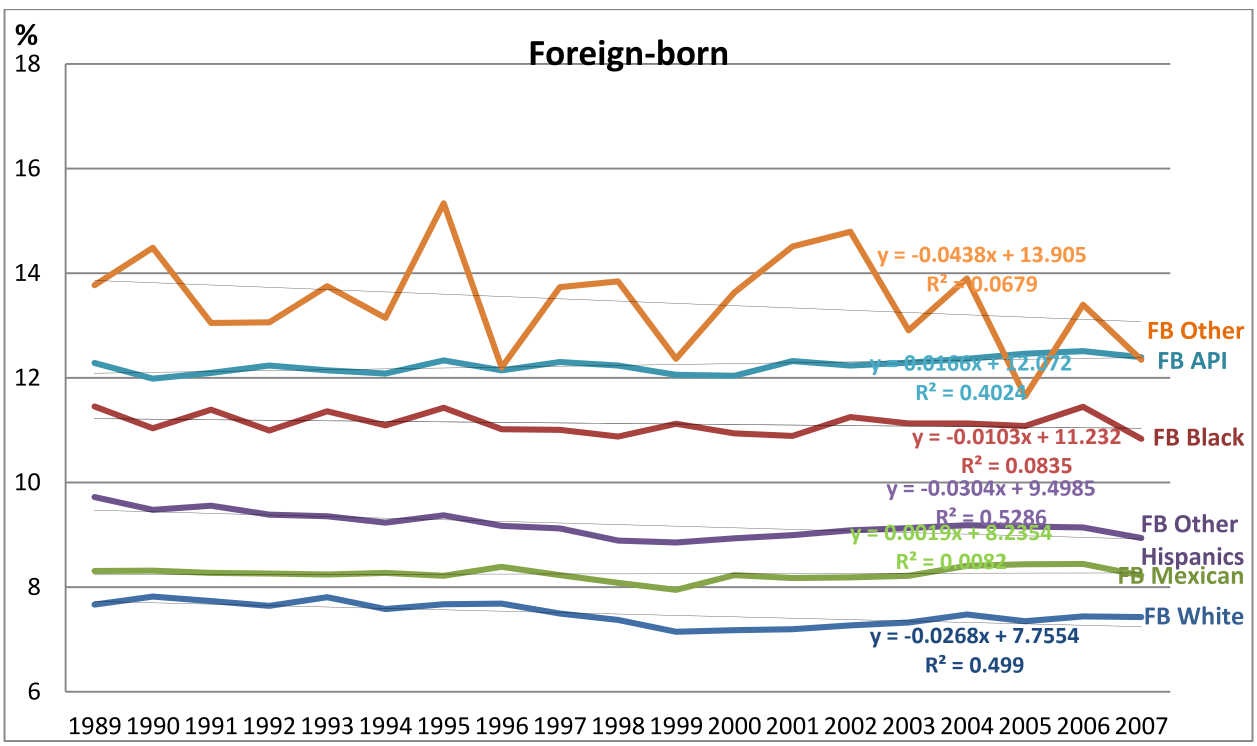
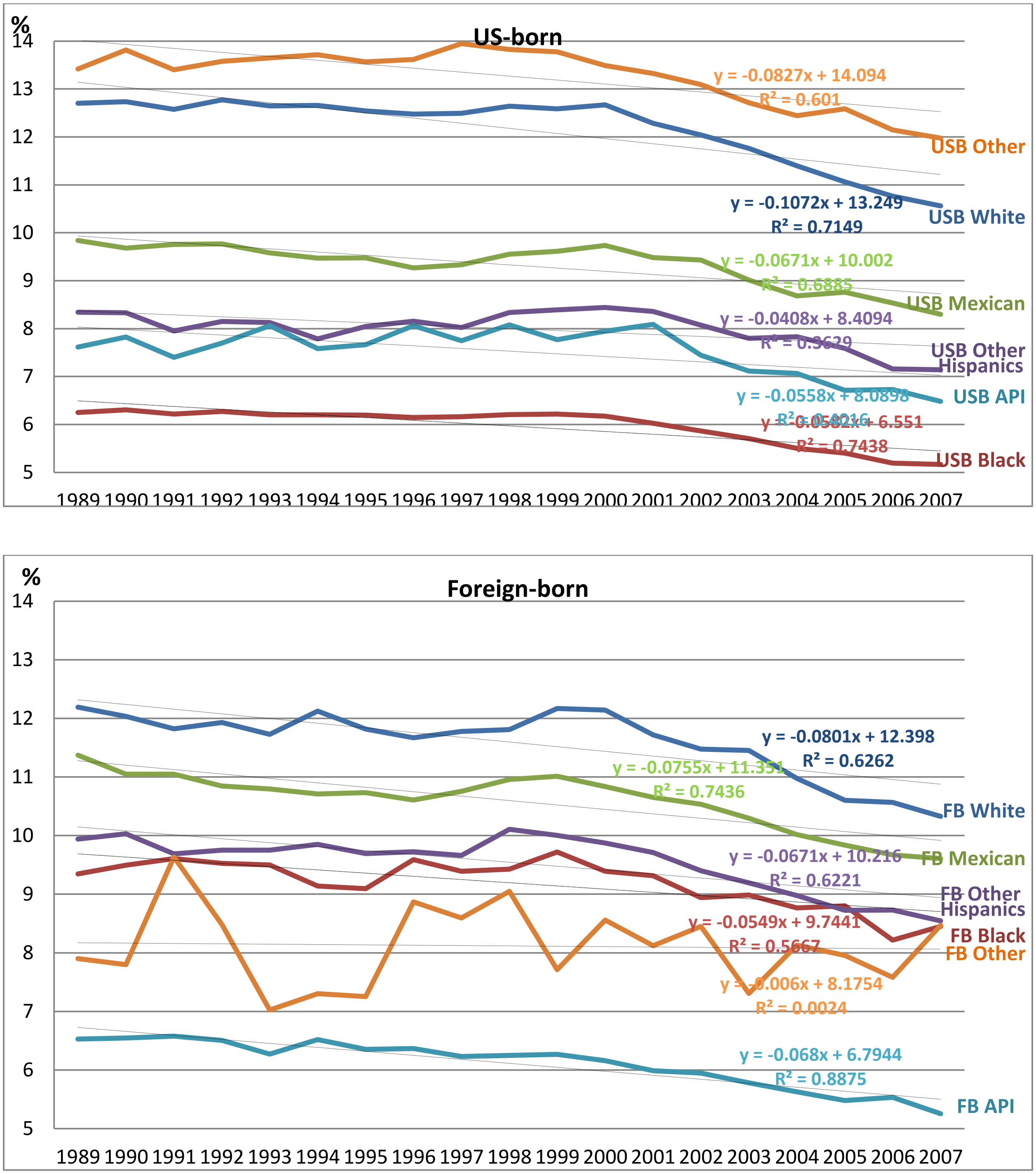


Figure 4.9 Trends in percent LGA singletons born to US-born and to foreign-born mothers by race/ethnicity, United States, 1989-2007



APPENDICES

Appendix A-1 Calculation for decomposing birthweight change between 1989 and 2007, All Births

	1989	2007				Birthweight Difference
Birthweight	3,373	3,303				70.0
	Col 1	Col 2	Col 3	Col4	Component E	Component C
	β_{1898}	$\bar{X}_{1989}$	β_{2007}	$\bar{X}_{2007}$	Col1*((Col2-Col4)	Col4 *(Col1-Col3)
Intercept	-741.9	0.0	-1230.6	0.0		488.7
Infant' Sex						
Male	131.2	0.5	120.0	0.5	0.1	5.8
Race						
US NH Black	-161.2	0.2	-158.1	0.2	-2.0	-0.5
US Mexican	-31.9	0.0	-31.8	0.1	1.2	0.0
FB Mexican	30.5	0.1	13.9	0.1	-2.4	2.3
Mother's Age						
Under 18	20.3	0.0	-14.9	0.0	0.2	1.3
18-20	-4.6	0.1	-32.4	0.1	0.0	2.1
20-24	-4.8	0.3	-19.0	0.3	0.0	3.8
35 and older	9.4	0.1	8.6	0.1	-0.5	0.1
Birth Order						
Second	84.6	0.3	87.5	0.3	1.5	-0.8
Third	122.7	0.2	119.1	0.2	0.4	0.7
Fourth and higher	144.4	0.2	134.9	0.2	-2.7	1.8
Missing	89.3	0.0	87.9	0.0	-0.3	0.0
Parity						
High Parity	-43.9	0.1	-34.7	0.1	-0.2	-1.3
1st birth and 35+	-48.5	0.0	-30.2	0.0	0.4	-0.4
Education						
High School Graduate	36.5	0.4	16.4	0.3	2.7	5.8
Associate Degree	56.6	0.2	37.3	0.2	-1.1	4.0
Bachelor's and higher	72.7	0.2	54.3	0.3	-9.0	5.2
Missing	33.0	0.1	2.3	0.0	2.6	0.3
Married						
Yes	45.5	0.7	31.0	0.6	6.6	8.5
Diabetes and Hypertension						
Both	41.3	0.0	12.6	0.0	-0.2	0.2

Diabetes Only	130.4	0.0	108.6	0.0	-2.4	0.8
Hypertension Only	-128.8	0.0	-156.4	0.0	1.7	1.2
Missing	-13.1	0.1	-3.3	0.0	-0.7	0.0
Weight Gain						
Under 15	-112.9	0.2	-78.3	0.3	9.5	-10.6
25 and up	138.9	0.2	120.6	0.3	-15.2	5.7
Missing	-14.2	0.3	4.8	0.1	-2.9	-1.1
Smoking						
Yes	-214.4	0.1	-177.1	0.1	-9.0	-4.0
Missing	-16.4	0.3	-35.5	0.1	-3.5	1.1
Prenatal Care						
Inadequate	-70.8	0.2	-44.5	0.1	-1.4	-3.9
Intermediate	-89.8	0.2	-74.7	0.1	-3.5	-1.7
Adequate Plus	-5.6	0.2	8.4	0.3	0.4	-4.3
Missing	-82.9	0.0	-31.9	0.0	1.7	-2.4
Induction						
Yes	24.0	0.1	30.7	0.2	-3.7	-1.6
Missing	3.6	0.1	-13.6	0.0	0.2	0.1
C-Section						
Yes	22.4	0.2	25.4	0.3	-2.1	-0.9
Missing	10.1	0.1	117.5	0.0	0.6	-0.4
Gestation (wk)						
Gestation	101.8	39.3	113.8	38.7	60.8	-463.7
				Total	**28.8**	**41.6**
				Percent	**40.9**	**59.1**

Appendix A-2 Calculation for decomposing birthweight change between 1989 and 2007, US-born non-Hispanic Whites

	1989	**2007**				**Birthweight Difference**
Birthweight	3,439	3,360				79.0
	Col 1	Col 2	Col 3	Col4 $\bar{X}_{2007}$	Component E	Component C
	β_{1898}	$\bar{X}_{1989}$	β_{2007}		Col1*((Col2-Col4)	Col4 *(Col1-Col3)
Intercept	-873.9		-1281.4			407.5
Infant' Sex						
Male	136.8	0.5	126.3	0.5	0.1	5.4
Mother's Age						
Under 18	24.9	0.0	3.4	0.0	0.2	0.5
18-20	0.9	0.1	-21.7	0.1	0.0	1.3
20-24	-2.4	0.2	-12.3	0.2	0.0	2.4
35 and older	4.6	0.1	9.4	0.1	-0.3	-0.7
Birth Order						
Second	89.9	0.3	92.1	0.3	1.6	-0.6
Third	129.0	0.2	121.4	0.2	1.0	1.3
Fourth and higher	155.0	0.2	138.5	0.2	-2.7	2.8
Missing	99.0	0.0	85.7	0.0	-0.3	0.1
Parity						
High Parity	-48.0	0.1	-42.5	0.1	-0.2	-0.6
1st birth and 35+	-43.1	0.0	-30.2	0.0	0.5	-0.3
Education						
High School Graduate	53.7	0.4	38.2	0.3	5.4	4.1
Associate Degree	76.3	0.2	62.7	0.2	-1.9	3.1
Bachelor's and higher	90.1	0.2	76.9	0.4	-17.3	5.1
Missing	56.6	0.1	19.7	0.0	5.0	0.2
Married						
Yes	50.5	0.8	39.1	0.7	6.5	8.0
Diabetes and Hypertension						
Both	27.2	0.0	24.3	0.0	-0.1	0.0
Diabetes Only	116.5	0.0	99.0	0.0	-2.0	0.6
Hypertension Only	-123.3	0.0	-141.6	0.0	1.9	0.9
Missing	-11.9	0.1	1.8	0.0	-0.6	-0.1
Weight Gain						
Under 15	-109.7	0.2	-74.0	0.3	5.7	-9.6
25 and up	141.7	0.2	126.4	0.3	-17.0	5.2
Missing	-2.1	0.2	20.1	0.0	-0.3	-1.0
Smoking						

Yes	-218.7	0.2	-179.2	0.1	-5.3	-5.7
Missing	-27.0	0.2	-47.6	0.1	-4.9	1.2
Prenatal Care						
Inadequate	-69.3	0.1	-48.0	0.1	-0.3	-2.3
Intermediate	-93.9	0.2	-75.8	0.1	-3.6	-2.1
Adequate Plus	-9.7	0.2	4.4	0.3	0.8	-4.6
Missing	-81.6	0.0	-40.2	0.0	1.3	-1.6
Induction						
Yes	28.0	0.1	33.2	0.3	-5.0	-1.5
Missing	9.8	0.0	-18.2	0.0	0.4	0.1
C-Section						
Yes	23.2	0.2	28.9	0.3	-2.0	-1.7
Missing	6.4	0.1	116.7	0.0	0.4	-0.4
Gestation (wk)						
Gestation	104.5	39.5	114.2	38.8	71.3	-376.6
				Total	**38.3**	**40.5**
				Percent	**48.6**	**51.4**

Appendix A-3 Calculation for decomposing birthweight change between 1989 and 2007, US-born non-Hispanic Blacks

	1989	2007				Birthweight Difference
Birthweight	3,124	3,092				32.0
	Col 1	Col 2	Col 3	Col4	Component E	Component C
	β_{1898}	$\bar{X}_{1989}$	β_{2007}	$\bar{X}_{2007}$	Col1*((Col2-Col4)	Col4 *(Col1-Col3)
Intercept	-862.7		-1719.1			856.4
Infant' Sex						
Male	115.2	0.5	114.0	0.5	-0.1	0.6
Mother's Age						
Under 18	33.1	0.1	7.7	0.1	1.4	1.8
18-20	11.8	0.1	-26.8	0.1	0.1	4.8
20-24	7.3	0.3	-19.6	0.3	-0.1	9.2
35 and older	22.7	0.1	-6.2	0.1	-0.7	2.4
Birth Order						
Second	53.7	0.3	68.4	0.2	1.2	-3.6
Third	76.1	0.2	93.8	0.2	1.1	-3.1
Fourth and higher	72.1	0.2	98.7	0.2	-1.1	-6.5
Missing	36.1	0.0	75.9	0.0	-0.2	-0.5
Parity						
High Parity	-19.1	0.2	-11.8	0.2	-0.3	-1.7
1st birth and 35+	-43.5	0.0	-16.5	0.0	0.2	-0.3
Education						
High School Graduate	25.0	0.4	24.4	0.4	1.0	0.2
Associate Degree	37.9	0.2	41.6	0.2	-2.6	-0.9
Bachelor's and higher	63.8	0.1	68.6	0.1	-4.7	-0.7
Missing	16.7	0.1	4.4	0.0	0.8	0.1
Married						
Yes	47.3	0.3	33.1	0.2	4.0	3.4
Diabetes and Hypertension						
Both	106.5	0.0	31.4	0.0	-0.6	0.6
Diabetes Only	204.2	0.0	177.2	0.0	-2.8	0.7
Hypertension Only	-125.8	0.0	-158.5	0.1	3.0	1.9
Missing	-9.0	0.1	-8.9	0.0	-0.5	0.0
Weight Gain						
Under 15	-127.7	0.3	-82.1	0.4	8.9	-16.2
25 and up	128.0	0.2	111.8	0.3	-14.1	4.6
Missing	-60.6	0.3	-9.1	0.1	-12.4	-3.9
Smoking						
Yes	-174.3	0.1	-131.3	0.1	-9.2	-3.7

Missing	-17.0	0.2	-18.0	0.1	-2.3	0.1
Prenatal Care						
Inadequate	-57.3	0.3	-28.1	0.2	-5.1	-6.1
Intermediate	-85.3	0.1	-79.7	0.1	-2.4	-0.6
Adequate Plus	27.3	0.2	19.7	0.3	-1.9	2.3
Missing	-71.5	0.0	-28.8	0.1	1.9	-3.1
Induction						
Yes	-4.7	0.1	25.8	0.2	0.7	-6.3
Missing	1.5	0.1	-12.5	0.0	0.1	0.1
C-Section						
Yes	10.3	0.2	5.7	0.3	-1.2	1.5
Missing	28.2	0.1	113.6	0.0	1.9	-0.3
Gestation (wk)						
Gestation	101.8	38.5	122.7	38.1	30.6	-796.2
				Total	**-5.3**	**37.1**
				Percent	**-16.7**	**116.7**

Appendix A-4 Calculation for decomposing birthweight change between 1989 and 2007, US-born Mexicans

	1989	2007				Birthweight Difference
Birthweight	3,345	3,284				61.0
	Col 1 β_{1898}	Col 2 $\bar{X}_{1989}$	Col 3 β_{2007}	Col 4 $\bar{X}_{2007}$	Component E Col1*((Col2-Col4)	Component C Col4 *(Col1-Col3)
Intercept	-211.8		-1014.2			802.4
Infant' Sex						
Male	114.3	0.5	102.5	0.5	0.0	6.0
Mother's Age						
Under 18	-34.6	0.1	-42.2	0.1	-0.3	0.7
18-20	-44.5	0.1	-47.5	0.1	-0.1	0.4
20-24	-22.2	0.3	-27.4	0.3	0.1	1.7
35 and older	19.9	0.1	-1.3	0.1	-0.2	1.3
Birth Order						
Second	67.7	0.3	79.8	0.3	0.8	-3.2
Third	94.4	0.2	109.7	0.2	0.8	-2.7
Fourth and higher	114.8	0.2	116.3	0.2	1.2	-0.3
Missing	94.9	0.0	47.0	0.0	-0.2	0.2
Parity						
High Parity	-29.3	0.2	-26.1	0.2	-0.3	-0.6
1st birth and 35+	-85.9	0.0	-38.5	0.0	0.3	-0.4
Education						
High School Graduate	20.3	0.4	15.2	0.4	-0.1	1.9
Associate Degree	34.0	0.1	25.5	0.2	-2.8	1.8
Bachelor's and higher	32.7	0.0	29.6	0.1	-2.7	0.4
Missing	11.6	0.1	8.6	0.0	1.2	0.0
Married						
Yes	35.6	0.7	21.4	0.5	7.5	6.5
Diabetes and Hypertension						
Both	91.9	0.0	-1.3	0.0	-0.3	0.5
Diabetes Only	153.0	0.0	144.3	0.0	-2.4	0.3
Hypertension Only	-164.6	0.0	-205.5	0.0	1.1	1.3
Missing	-25.6	0.1	20.6	0.0	-3.6	-0.1
Weight Gain						
Under 15	-118.1	0.2	-84.0	0.3	18.8	-10.9
25 and up	123.7	0.1	113.5	0.3	-22.8	3.1
Missing	-27.1	0.5	14.9	0.1	-12.9	-2.9
Smoking						
Yes	-161.2	0.0	-111.8	0.0	-2.3	-1.7

Missing	50.3	0.5	3.8	0.0	22.3	1.2
Prenatal Care						
Inadequate	-55.7	0.3	-48.3	0.2	-4.9	-1.4
Intermediate	-73.7	0.2	-73.7	0.1	-4.0	0.0
Adequate Plus	1.5	0.2	11.8	0.3	-0.2	-3.0
Missing	-57.0	0.0	-12.2	0.1	1.6	-2.7
Induction						
Yes	19.6	0.1	31.5	0.2	-2.6	-2.3
Missing	-9.5	0.1	-12.2	0.0	-1.2	0.0
C-Section						
Yes	33.1	0.2	30.5	0.3	-3.0	0.7
Missing	2.1	0.1	112.8	0.0	0.3	-0.3
Gestation (wk)						
Gestation	88.2	39.1	108.2	38.6	46.8	-773.1
				Total	**35.7**	**24.6**
				Percent	**59.2**	**40.8**

Appendix A-5 Calculation for decomposing birthweight change between 1989 and 2007, US-born Mexicans

	1989	2007				Birthweight Difference
Birthweight	3,345	3,284				61.0
	Col 1	Col 2	Col 3	Col 4	Component E	Component C
	β_{1898}	$\bar{X}_{1989}$	β_{2007}	$\bar{X}_{2007}$	Col1*((Col2-Col4)	Col4 *(Col1-Col3)
Intercept	-50.1		-597.7			547.6
Infant' Sex						
Male	119.2	0.5	105.8	0.5	0.0	6.9
Mother's Age						
Under 18	-48.4	0.0	-50.1	0.0	-0.5	0.1
18-20	-49.3	0.1	-46.9	0.1	-0.8	-0.2
20-24	-23.7	0.3	-25.9	0.3	-1.4	0.6
35 and older	13.0	0.1	7.9	0.1	-0.6	0.6
Birth Order						
Second	101.1	0.3	92.8	0.3	-2.0	2.3
Third	148.7	0.2	135.9	0.2	-5.5	2.8
Fourth and higher	196.0	0.2	166.1	0.2	1.1	6.7
Missing	93.4	0.0	137.8	0.0	-0.3	-0.2
Parity						
High Parity	-32.1	0.2	-30.2	0.1	-0.8	-0.3
1st birth and 35+	-50.7	0.0	-18.2	0.0	0.2	-0.3
Education						
High School Graduate	-1.1	0.2	-5.5	0.2	0.1	1.1
Associate Degree	-11.7	0.1	-8.6	0.1	0.1	-0.2
Bachelor's and higher	-22.2	0.0	-13.9	0.1	0.7	-0.4
Missing	-2.6	0.1	-4.1	0.0	-0.1	0.0
Married						
Yes	32.3	0.7	5.4	0.5	5.6	14.2
Diabetes and Hypertension						
Both	11.1	0.0	-69.0	0.0	0.0	0.3
Diabetes Only	139.2	0.0	76.5	0.0	-4.3	2.9
Hypertension Only	-214.9	0.0	-236.4	0.0	1.4	0.5
Missing	-12.3	0.1	-11.2	0.0	-0.8	0.0
Weight Gain						
Under 15	-103.2	0.1	-93.0	0.4	30.9	-4.1
25 and up	118.6	0.0	102.8	0.2	-16.8	3.0
Missing	-34.4	0.8	-38.6	0.1	-22.8	0.4
Smoking						
Yes	-128.1	0.0	-102.2	0.0	-0.8	-0.1

Missing	43.6	0.7	-3.0	0.0	28.0	1.9
Prenatal Care						
Inadequate	-60.2	0.4	-40.3	0.2	-10.0	-4.6
Intermediate	-50.8	0.2	-55.5	0.1	-3.8	0.6
Adequate Plus	-1.4	0.1	13.5	0.3	0.2	-3.7
Missing	-63.3	0.0	-11.5	0.1	1.8	-3.0
Induction						
Yes	1.3	0.0	19.6	0.1	-0.1	-2.5
Missing	-6.0	0.1	2.2	0.0	-0.3	0.0
C-Section						
Yes	57.1	0.2	30.1	0.3	-6.3	7.5
Missing	-5.2	0.1	119.4	0.0	-0.3	-0.3
Gestation (wk)						
Gestation	84.4	39.3	98.7	38.8	40.0	-554.3
				Total	**31.7**	**25.7**
				Percent	**55.2**	**44.8**

Appendix B. Percentage of missing data and imputed data by year of data collection

Datayear	Missing	Imputed
1989	6.5	16.1
1990	3.6	15.7
1991	2.5	15.2
1992	2.5	14.4
1993	2.4	14.1
1994	2.2	13.7
1995	2.7	14.4
1996	2.7	13.1
1997	2.6	12.6
1998	2.5	12.6
1999	2.6	12.3
2000	2.5	12.0
2001	2.0	10.8
2002	2.0	9.8
2003	2.1	5.8
2004	2.2	7.8
2005	1.9	11.4
2006	1.7	13.2
2007	1.3	14.2

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